ATTACHEMENT A

Memorandum for File:
Sutter Basin Pilot Feasibility Study,
Hydraulic Analysis of Refined Alternatives
8 June 2012

CESPK-ED-HA 8 June, 2012
23 Oct, 2012 Rev

MEMORANDUM FOR FILE: Sutter Basin Pilot Feasibility Study

SUBJECT: Hydraulic Analysis of Refined Alternatives.

1. REFERENCES:

a. DWR, 2012, Urban Levee Design Criteria, State of California Department of Water Resources, May 2012
b. USACE, 1957, Levee and Channel Profiles, Sacramento River Flood Control Project, File No. 50-10-3334, 4-sheets. 15 March 1957
c. USACE, 1995, Engineering and Design Hydrologic Engineering Requirements for Flood Damage Reduction Studies, EM 1110-2-1419, 31 Jan 1995.
d. USACE, 2002, Sacramento San Joaquin Comprehensive Study, Appendix B-Synthetic Hydrology, December 2002
e. USACE, 2008, Yuba River Basin Project, General Reevaluation Project, Appendix A, Synthetic Hydrology and Reservoir Operations Technical Documentation, April 2004 (Corrected June 2008).
f. USACE, 2010, USACE Process for the National Flood Insurance Program (NFIIP) Levee System Evaluation. 31 August 2010.

2. PURPOSE:

The purpose of this memorandum is to describe hydraulic analysis conducted in support of the Sutter Basin Feasibility Study. A map of the watershed is included as Plate 1 and a map of the study area is included as Plates 2 and 3. The memo documents refined analysis of the existing conditions, without project conditions and alternatives. Identification and evaluation of the alternatives that are refined in this analysis are presented in the report, Sutter Basin Feasibility Study, Progress Document 1, Without Project and Alternative Development.

All elevations provided herein are relative to the NAVD88 vertical datum and NAD83 Horizontal datum. Horizontal coordinates are projected to the California State Plane Zone III coordinate system. The conversion between NAVD88 and NGVD29 ranges from 2.3 to 2.4 feet in this area. Expressed as an equation, the conversion is Elevation (NGVD29) = Elevation (NAVD88) minus 2.40 feet.

3. BACKGROUND:

a. General. A high risk of flooding from levee failure threatens the public safety of approximately 80,000 people, as well as property and critical infrastructure throughout the Sutter Basin study area. Past flooding has caused loss of life and extensive economic damages. Recent geotechnical analysis and evaluation of historical performance during past floods indicate the project levees do not meet U.S. Army Corps of Engineers (USACE) levee design standards and are at risk of breach failure at stages less than overtopping. Within the study area, as throughout the Sacramento Valley, floodplain and native habitats have been lost or degraded. Federally listed species and other special status species that are dependent on floodplain habitats have declined. Opportunities exist to restore land formerly converted by mining or agriculture to more natural habitats through Ecosystem Restoration (ER) in conjunction with flood risk management (FRM). There are also opportunities to provide outdoor recreational features on FRM and ER project lands. The purpose of the Sutter Basin Feasibility Study is to address FRM in conjunction with ER and recreation.

b. Alternatives. Alternative plans were evaluated through an iterative planning process. The alternatives evaluated in this memorandum are considered to be the refined array and were the outcome of multi-disciplinary analysis at two levels of increasing detail. Throughout this process the concept of absolute accuracy versus relative accuracy was considered. At each level of analysis the assessment of the existing and without project conditions was improved. Although it would appear that every plan should be compared to the most accurate assessment of existing conditions, this is not necessary because the relative accuracy between plans is sufficient to select the most optimal plan to move forward.

Conceptual alternatives were developed from a broad array of measures. The measures were evaluated at a qualitative level of detail using hydraulic assumptions and calculations. The measures were then combined into conceptual alternatives during a planning Charrette attended by the project sponsors and subject matter experts. Development of the conceptual alternatives is described in Progress Document 1.

Refined alternatives were derived from the conceptual alternatives. The conceptual alternatives described above were evaluated using qualitative and quantitative engineering analyses. Analyses included floodplain hydraulic modeling, cost estimating, and economic benefit estimations. The level of detail was limited to that required to decide which plans to carry forward. Results were evaluated at a combined VE study and planning charette attended by the project sponsors and subject matter experts. At the conclusion of the planning charette, a refined array of alternatives was identified for further analysis. Analysis of the refined array of alternatives is described in this report.

4. STUDY AREA:

a. General. The study area covers approximately 300 square miles and is approximately 43 miles long and 9 miles wide. The primary sources of flooding within the study area are the Butte Basin, Sutter Bypass, Feather River, Cherokee Canal, Wadsworth Canal, and local interior drainage.

The study area includes the communities of Yuba City, Live Oak, Gridley, Biggs, and Sutter with a total population of approximately 80,000. Yuba City is the largest community in the study area, with a population of approximately 65,000. A map of population density within the study area is provided in Plate 4. The majority of land use in the study area is related to agricultural. A map of land use types in the study area is presented in Plate 5.

b. Topography. Elevations within the study area range from 110 ft NAVD88 in the north to 30 ft NAVD88 in the south. The study area has a general slope from northeast to south west. The general slope of the study area is interrupted by two major linear features which would impact hydraulic conveyance within the study area if a levee breach were to occur. The raised embankment of the Union Pacific Railroad traverses the study area in a north south alignment. The Sutter Bypass east levee traverses the study area in a north south alignment. A topographic map of the study area is presented in Plate 2.

c. Stream Gages: A list of applicable stream gages within the study area is provided in Table 1. The stream gages are operated by the United States Geological Survey (USGS) and California Department of Water resources. Steam gages shown on Plate 7.

Table 1 Stream Gages, Sutter Basin Study Area

Gage Name	Area (Sq Mi)	Agency	Gage Number	Period of Record	Type
Bear R Nr Wheatland Ca	292	USGS	11424000	1928-2010	S,Q
Bear River at Pleasant Grove	300	DWR	A06535	1987-2010	S,Q
Butte Creek near Gridley	NA	DWR	A04150	1991-1999	S,Q
Butte Slough at Outfall Gates near Colusa	NA	WDL	A02967	1992-2010	S
Butte Slough near Meridian	NA	WDL	A02972	1981-2010	S,Q
Cherokee Canal nr Gridley	NA	DWR	A00910	1991-1998	S,Q
Cherokee Canal nr Richvale	NA	DWR	A02984	1976-2010	S,Q
Camp Far West Reservoir	NA	DWR	A65105	1998-2010	Q
Colusa Weir Spill to Butte Basin near Colusa	NA	WDL	A02981	1975-2010	S,Q
Deer C Nr Smartville CA	84.6	USGS	11418500	1935-2010	S,Q
Feather River at Nicholaus	5,921	DWR	A05103	1942-2010	S,Q(P)
Feather River at Oroville	3,624	USGS	11407000	1902-2010	S,Q
Feather River at Yuba City	3,974	DWR	A05135	1964-2010	S
Feather River near Gridley	3,676	DWR	A05165	1964-2010	S,Q
Moulton Weir Spill to Butte Basin nr Colusa	NA	DWR	A02986		
Sacramento R at Colusa Ca	12,090	USGS	11389500	1941-2010	S,Q
Sacramento R at Verona Ca	21,251	USGS	11425500	1929-2010	S,Q
Sacramento R Blw Wilkins Slough nr Grimes Ca	12,915	USGS	11390500	1931-2010	S,Q
Sacramento River at Butte Slough Outfall Gates	NA	DWR	A02400	1992-2004	S
Sacramento River at Fremont Weir (East)	NA	DWR	A02160	1935-2010	S
Sacramento River at Fremont Weir (West)	NA	DWR	A02170	1934-2010	S
Sacramento River at Knights Landing	14,535	DWR	A02200	1982-2010	S
Sacramento Slough near Karnak	NA	DWR	A02925	1981-2010	S
Sutter Bypass at R.D. 1500 P.P. near Karnak	NA	DWR	A02927	1975-2010	S
Sutter Bypass Channel at Pumping Plant #1	NA	DWR	SB1	2008-2010	S
Sutter Bypass Channel at Pumping Plant #2	NA	DWR	SB2	2008-2010	S
Sutter Bypass Channel at Pumping Plant #3	NA	DWR	SB3	2008-2010	S
Tisdale Weir near Grimes	NA	DWR	A02960	1975-2010	S,Q
Willow Slough near Nicolaus	NA	DWR	A02943	1991-2010	S
Yolo Bypass nr Woodland Ca	NA	USGS	11453000	1939-2011	S,Q
Yuba R blw Englebright Dam near Smartsville	1,108	USGS	11418000	1941-2011	S,Q
Yuba R Nr Marysville CA	1,339	USGS	11421000	1940-2011	S,Q
Wadsworth Canal near Sutter (lower)	96	DWR	A05927	1982-1997	S,Q
Wadsworth Canal near Sutter (upper)	96	DWR	A05929	1976-1997	S,Q
Note: S-Stage, Q-Discharge, NA- Not Available, (Partial Record)					

5. SOURCES OF FLOODING:

The following describes significant sources of flooding within the study area.

a. Butte Basin. The Butte Basin is a natural overflow and flood storage area north west of the Sutter Buttes and east of the Sacramento River. The basin provides approximately 1 million acre-feet of transitory storage at flood stage (DWR, 2010). Excess floodwaters from the Sacramento River enter the Butte Basin via overbank areas along the river and through the Moulton and Colusa weirs. Butte Creek and its tributaries, including Cherokee Canal, also flow into the Butte Basin. Outflow from the Butte Basin is regulated by hydraulic conditions of Butte Slough and floodplain

topography at the upstream entrance to the Sutter Bypass. In order to maintain the flood storage capabilities within Butte Basin, California has included regulation of the overflow area in Title 23 of the California Code of Regulations. In general these standards require approval from the board for any encroachments that could reduce or impede flood flows or would reclaim any of the floodplain within the Butte Basin (DWR, 2010).

b. Sutter Bypass. The Sutter Bypass is a leveed flood control channel approximately three quarters of a mile wide, bordered on each side by levees. The bypass is an integral feature of the Sacramento River Flood Control Project's flood bypass system. The Sutter Bypass conveys flood waters from the Butte Basin, Sacramento River, and Feather River to the confluence of the Sacramento River and Yolo Bypass at Fremont Weir.

Downstream of the Feather River, the bypass is separated into two conveyance areas by a low levee. The area east of the middle levee conveys the Feather River. This design maintains higher velocities and sediment transport capacity within the Feather River during low flow events while utilizing the large conveyance of the Sutter Bypass during larger events.

The Sutter Bypass also receives minor natural flow and agricultural return flow from Reclamation District 1660 to the west and from Wadsworth Canal and DWR pumping plants 1, 2, and 3 to the east. The Sutter Bypass is described by four hydrologic reaches based on tributary inflows; Butte Slough to Wadsworth Canal, Wadsworth Canal to Tisdale Bypass, Tisdale Bypass to Feather River, Feather River to Sacramento River.

c. Feather River. The Feather River is a major tributary to the Sacramento River, merging with the Sutter Bypass upstream from the Sacramento River and Fremont Weir. The Yuba and Bear Rivers are major tributaries to the Feather River. Two major flood management reservoirs are located within the Feather River watershed. Oroville Dam and reservoir was completed on the Feather River in 1967. The reservoir has 3,358,000 acre-feet of storage with 750,000 acre-feet of dedicated flood management space. New Bullards Bar dam and reservoir was completed on the Yuba River 1970. The reservoir has 966,000 acre-feet of storage with 170,000 acre-feet of dedicated flood management space. The Feather River is described by four hydrologic reaches based on significant inflows; Thermalito to Honcut Creek, Honcut Creek to Yuba River, Yuba River to Bear River, and Bear River to Sutter Bypass.

d. Cherokee Canal. The Cherokee Canal is a tributary to Butte Creek and the Butte Basin. The leveed canal was constructed between 1959 and 1960 by USACE. The canal drainage area is 94 square miles and varies in elevation from 70 feet to 2200 feet. The drainage area is bounded by the Feather River watershed to the east and southeast, Butte Creek and its tributaries to the north and west, and by Wadsworth Canal drainage to the south.

e. Wadsworth Canal. The Wadsworth Canal is a leveed tributary to the Sutter Bypass near the town of Sutter. The canal conveys flow from the East and West interceptor canals to the Sutter Bypass. The East and West interceptor canals collect runoff from 96 square miles of into the Wadsworth Canal.

6. RECENT FLOODS:

The following is a description of recent significant flood events within the study area. The magnitudes of historical floods are difficult to compare due to significant historical changes in the flood management system.

a. December 1955. The last major flood to damage the study area occurred in December 1955 when the west levee of the Feather River breached near Shanghai Bend. The peak flow measured at the Feather River at Oroville stream gage was 203,000cfs. This flood occurred prior to construction of Oroville and New Bullards Bar reservoirs. Therefore, the flood does not reflect existing hydrologic conditions. A hypothetical flood routing of the 1955 flood is presented in the Oroville Dam water control manual. The flood routing indicates the reservoir would have regulated the peak outflow to 150,000cfs.

b. November 1982 - March1983. Water year 1983 was a result of the “El Niño” weather phenomenon. Northern and Central California experienced flooding incidents from November through March due to numerous storms. In early May, snow water content in the Sierra exceeded 230 percent of normal, and the ensuing runoff resulted in approximately four times the average volume for Central Valley streams. System failures in the Sacramento River Basin were limited to a private levee on the Sacramento River and one failure on Cache Creek.

c. February 1986. Flooding in 1986 resulted from a series of four storms over a 9-day period during February. Rains from the first three storms saturated the ground and produced moderate to heavy runoff before the arrival of the fourth storm. Precipitation at Four Trees in the Feather River Basin set both a 24-hour rainfall record for the Sierra Nevada and the monthly record for any station in the State. System breaks in the Sacramento River Basin included disastrous levee breaks in the Olivehurst and Linda area on the Feather River, adjacent to the study area.

d. January 1995. "El Nino" conditions in the Pacific forced major storm systems directly into California during much of the winter and early spring of 1995. The largest storm systems hit California in early January and early March. The major brunt of the January storms hit the Sacramento River Basin and resulted in small stream flooding primarily due to storm drainage system failures.

e. January 1997. December 1996 was one of the wettest Decembers on record. Watersheds in the Sierra Nevada were already saturated by the time three subtropical storms added more than 30 inches of rain in late December 1996 and early January 1997. The third and most severe of these storms lasted from December 31, 1996, through January 2, 1997. Rain in the Sierra Nevada caused record flows that stressed the flood management system to capacity in the Sacramento River Basin and overwhelmed the system in the San Joaquin River Basin. Levee failures due to breaks or overtopping in the Sacramento River Basin resulted in extensive damages.

f. December 2005 - January 2006. Between 28 December 2005 and 9 January 2006, the State of California experienced a series of severe storms which impacted the levees within the Sacramento District's boundaries. Water rose a second time in April 2006, and remained high in some parts of the system until June. Many rivers and streams within the Sacramento and San Joaquin River systems ran above flood stage during these events, and there were significant erosion and seepage problems with the levees. The State of California Department of Water Resources and/or their maintaining agencies conducted the actual flood fight activities while the U.S. Army Corps of Engineers provided technical assistance to the State.

7. FLOOD RISK ASSESSMENT APPROACH

Flood risk is defined as the probability of a flood event occurring and the consequences of occurrence. Flood risk was assessed using the USACE FDA model approach and is described in the economics report. The report presents results for seven economic impact areas within the study area. A map of the economic impact areas is presented as Plate 6.

The FDA approach combines flow-frequency, stage-discharge, geotechnical fragility, and stage-damage relationships to estimate damages. Uncertainty in each relationship is incorporated by assigning uncertainty estimates and applying a Monte Carlo type approach to combine the results.

Flow-frequency, stage discharge, and geotechnical frequency relationships reflect the exterior (probability) side of the risk calculations. Inundation depth and stage-damage relationships reflect the interior (consequence) side of the risk calculations. For the probability side of the risk calculations, the hydraulic model assumptions are based on flows contained to the channel (allowed to overtop without failure). For the consequence side of the risk calculations, the hydraulic model assumptions are based on levee breach failure or simply the depth for natural overbank (non-levee) conditions.

The first step in the risk assessment approach was evaluation of potential flood sources with respect to geotechnical fragility, channel hydrology, channel hydraulics, and potential inundation patterns of a levee breach natural overbank (non-levee). Thirteen geotechnical reaches were identified. Within each of these geotechnical reaches a

representative geotechnical fragility curve was developed and a stage-discharge relationship was developed using a hydraulic model (see below). Selection of the geotechnical reaches is described in detail in the geotechnical analysis. Fifteen breach sources and one non-leveed flood source locations were identified. All flood source locations identified within a geotechnical reach were assigned to the same geotechnical fragility curve location.

8. FLOOD RISK MAPS

The performance of existing Flood Risk Management features varies by reach. Performance was evaluated using the HEC-FDA computer program and is discussed in detail in the economics section. Levee performance is expressed as an assurance level (conditional non-exceedance probability) for a given median ACE hydrologic event.

Maps showing residual flood risk were developed to demonstrate FRM performance levels relative to a standard assurance criterion. The maps show inundation from any flood source that would not meet an assurance criterion. Maps were developed for each of two assurance criteria.

a. Assurance Criteria#1. This criterion was based on the deterministic approach required by FEMA for 1% ACE and DWR for 0.5% ACE. To meet this criteria a levee reach must have a minimum of 3 feet of freeboard for Hydrology and Hydraulic capacity for the given flood event. The geotechnical performance of a levee reach must meet current USACE geotechnical and civil design standards for the given design flood event. This assurance criterion was used to define residual risk maps for all Annual Chance Exceedance (ACE) events.

b. Assurance Criteria #2. This criterion was based on the NFIP levee system analysis criteria described in EC 1110-2-6067 and was adopted for use in describing the performance of all ACE events. This criterion is described as “Option 2” in the DWR Urban Levee Design Criteria. Assurance values were based on an USACE FDA risk and uncertainty analysis which included hydrologic uncertainty, hydraulic uncertainty, and geotechnical fragility curves. All values are relative to the median stage for each ACE event. 1) For assurance less than 90% the levee does not pass criteria 2) For assurance between 90 and 95% levee must have minimum of 3 feet of freeboard to pass criteria. 3) For assurance greater than 95% levee must have minimum of 2 feet of freeboard to pass criteria. Other requirements described in EC1110-2-6067 are not included. For example, operations and maintenance requirements are not included in the criteria.

9. EXISTING CONDITION CHANNEL MODEL

Water surface profiles were computed using HEC-RAS and HEC-UNET one-dimensional flow models. HEC-RAS and UNET calculate steady or unsteady gradually

varied flow in natural and manmade channels by performing step-backwater calculations of the 1-D flow energy equation through a series of input geometric cross-sections with empirically defined hydraulic roughness coefficients.

An unsteady system-wide HEC-RAS model was used for the Sacramento River, Feather River, and Sutter Bypass. A steady state HEC-RAS model was used for the Wadsworth Canal. An unsteady HEC-RAS model was used for Cherokee Canal. An unsteady HEC-UNET model developed for the Sacramento-San Joaquin Comprehensive study was used for Butte Basin flood depths. A map of the HEC-RAS hydraulic models cross sections and location of boundary conditions is provided as Plate 7. The following describes hydraulic model input to the FDA hydraulic model and also used in the assessment of project performance and assurance.

a. Non-Failure Infinite Height Levee Profiles. Models were developed to evaluate two profile scenarios. Scenario A assumed all levees were infinitely high and would contain all flows without overtopping. This scenario was used to evaluate the sensitivity of downstream flow conditions relative to upstream overtopping assumptions. The resulting model profiles are provided in Plates 8, 9, 10, and 11.

b. Non-Failure Overtopping Profiles. Scenario B assumed all levees were overtopped without failure. Scenario B was used in the economic FDA analysis. The resulting model profiles are provided in Plates 8, 9, 10, and 11. As described above, these median profiles are for use in the FDA flood damage assessment model. The profiles do not account for risk and uncertainty which is required to evaluate assurance. Assurance estimates are provided in the economics report.

c. Breach Hydrographs. Simulations were performed for fifteen levee breach flood sources and one natural (non-leveed) flood source. These sources were spatially distributed throughout the study area. Breach locations were selected to represent similar levee and floodplain characteristics. All breach scenarios assume levees were overtopped without failure at all locations other than the breach location. Eight breaches were simulated on the Feather River from Thermalito to Sutter Bypass. Two breaches were simulated on the Sutter Bypass between Wadsworth Canal and Feather River. Two breaches were simulated on Cherokee Canal upstream and downstream of the Union Pacific Railroad. A single breach was simulated on Wadsworth Canal. All breach simulations assume remaining levee reaches would be overtopped without failure. In order to simplify the analysis, breaches were assumed to exist at the start of each flood hydrograph simulation.

c. Stage Uncertainty. Stage uncertainty arises from the use of simplified models to describe complex hydraulic phenomena, including the lack of detailed geometric data, misalignments of hydraulic structures, debris load, infiltration rates, embankment failures, material variability, and from errors in estimating slope and roughness factors.

A standard deviation in stage of 1.5 feet was used for hydraulic uncertainty. This value was estimated following methods in EM-1110-2-1619. The total stage uncertainty was based on the geometric mean of natural and model uncertainty. The total stage uncertainty was based on standard deviations of 0.75 ft and 1.3 feet for natural and model uncertainty respectively.

10. EXISTING CONDITION FLOODPLAIN INUNDATION MODEL

Floodplain inundation was simulated using a FLO-2D two dimensional hydrologic model of the Study Area. The without project condition FLO-2D model was modified from existing USACE models by the Sutter Butte Flood Control Agency as work in kind credit for the study. Models and results underwent Independent Technical Review and District Quality Control. The model includes significant floodplain features which can interfere with the flood conveyance in the floodplain. For example, the model includes railroad embankments and culverts. A map showing the FLO-2D model domain is provided as Plate 12.

a. Breach Scenarios. For each hydrologic frequency event, floodplain inundation breach maps were developed for the fifteen levee breaches and one natural (non-leveed) flood sources throughout the study area. The inundation maps simulate a levee breach during the flood event. The inflow to the FLO-2D model was the outflow from the HEC-RAS model. The specified frequency is not the frequency of inundation. Inundation frequency estimates must account for performance of the levee (probability of the breach). The inundation frequency is computed in the economic flood damage analysis using the geotechnical fragility curves. Simulated inundation maps for levee breaches during a 100-yr event are provided as plates 13 through 28. Digital maps generated for simulated breaches during other ACE flood events are available upon request.

11. REFINED ALTERNATIVES.

The following describes the hydraulic design of new levees, project performance, and residual floodplains for each of the refined project alternatives.

d. SB-1 No Action. Based on a review of historical conditions and proposed actions, the hydraulic conditions in the future are assumed to be the same as existing conditions. Residual flood risk maps for criteria #1 and #2 are presented in Plates 29 and 30 respectively.

e. SB-2 Minimal Fix-In-Place plus NonStructural. This alternative would increase the performance of the levee from Sunset Weir to Star Bend. Residual Flood Risk Maps were based on reducing the fragility curve to overtopping only for breach locations FR6.0R, FR5.0R, and FR4.5R. Residual flood risk maps for criteria #1 and #2 are presented in Plates 31 and 32 respectively.

f. SB-3 Yuba City Ring Levee. This alternative would involve construction of a ring levee around Yuba City. The height of the ring levee was determined by reviewing the flood elevations from the hypothetical levee breaches. Wind wave runup analysis was also conducted and the levee height was increased as necessary to provide 95% assurance from a levee breach outside the ring levee during a 0.5% (1/200) ACE flood. The hypothetical levee breach simulations were conducted for the 0.2% (1/500) ACE flood event with the levee in place. The resulting levee design profile is provided as Plate 33. Residual flood risk maps were based on reducing the fragility curve to overtopping only for breach locations FR5.0R and FR4.5R. Residual flood risk maps for criteria #1 and #2 are presented in Plates 34 and 35 respectively.

g. SB-4 Yuba City J-Levee. This alternative would involve fixing the levees from Thermalito to Shanghai Bend and construction of a partial ring levee around Yuba City. The height of the new portion of levee was determined by reviewing the flood elevations from the hypothetical levee breaches. Wind wave runup analysis was also conducted and the levee height was increased as necessary to provide 95% assurance from a levee breach during a 0.5% (1/200) ACE flood in the unfixed levees. The hypothetical levee breach simulations were conducted for the 0.2% (1/500) ACE flood event with the levee in place. The resulting levee design profile is provided as Plate 36.Residual flood risk maps were based on reducing the fragility curve to overtopping only for breach locations on the Feather River FR9.0R, FR8.0R, FR7.0R, FR6.0R, FR5.0R, and FR4.5R. Residual flood risk maps for criteria #1 and #2 are presented in Plates 37 and 38 respectively.

h. SB-5 Fix in Place Feather River, Thermalito to Star Bend. This alternative would involve fixing the levees from Thermalito to Star Bend. The hypothetical levee breach simulations are the same as the no action plan. Residual flood risk maps were based on reducing the fragility curve to overtopping only for breach locations on the Feather River FR9.0R, FR8.0R, FR7.0R, FR6.0R, FR4.5R. Residual flood risk maps for criteria #1 and #2 are presented in Plates 39 and 40 respectively.

i. SB-6 Fix in Place Feather River, Sutter Bypass and Wadsworth Canal. This alternative would involve fixing the east levee of the Sutter Bypass downstream of Wadworth Canal, Wadsworth Canal south levee and Feather River west levee. The hypothetical levee breach simulations are the same as the no action plan. Flood Residual flood risk maps were based on reducing the fragility curve to overtopping only for all breach locations except BB1.0, CC2.0L,CC1.0L, SB 5.0L, and BW2.0R. Residual flood risk maps for criteria #1 and #2 are presented in Plates 41 and 42 respectively.

j. SB-7 Fix-In-Place Sunset Weir to Laurel Avenue . This alternative would increase the performance of the levee from Sunset Weir to 2200 feet downstream of Laurel Ave. Residual Flood Risk Maps were based on reducing the fragility curve to overtopping only

for breach locations FR6.0R, FR5.0R, and FR4.5R, and FR4.0R. Residual flood risk maps for criteria #1 and #2 are presented in Plates 43 and 44 respectively.

k. SB-8 Fix in Place Feather River, Thermalito to Laurel Avenue. This alternative would involve fixing the levees from Thermalito to 2200 feet downstream of Laurel Ave. The hypothetical levee breach simulations are the same as the no action plan. Residual flood risk maps were based on reducing the fragility curve to overtopping only for breach locations on the Feather River FR9.0R, FR8.0R, FR7.0R, FR6.0R, FR4.5R, and FR4.0R. Residual flood risk maps for criteria #1 and #2 are presented in Plates 45 and 46 respectively.

12. CONCLUSIONS

For questions on the technical content of this report, contact Peter Blodgett, P.E., Hydraulic Design Section, (916) 557-7529.

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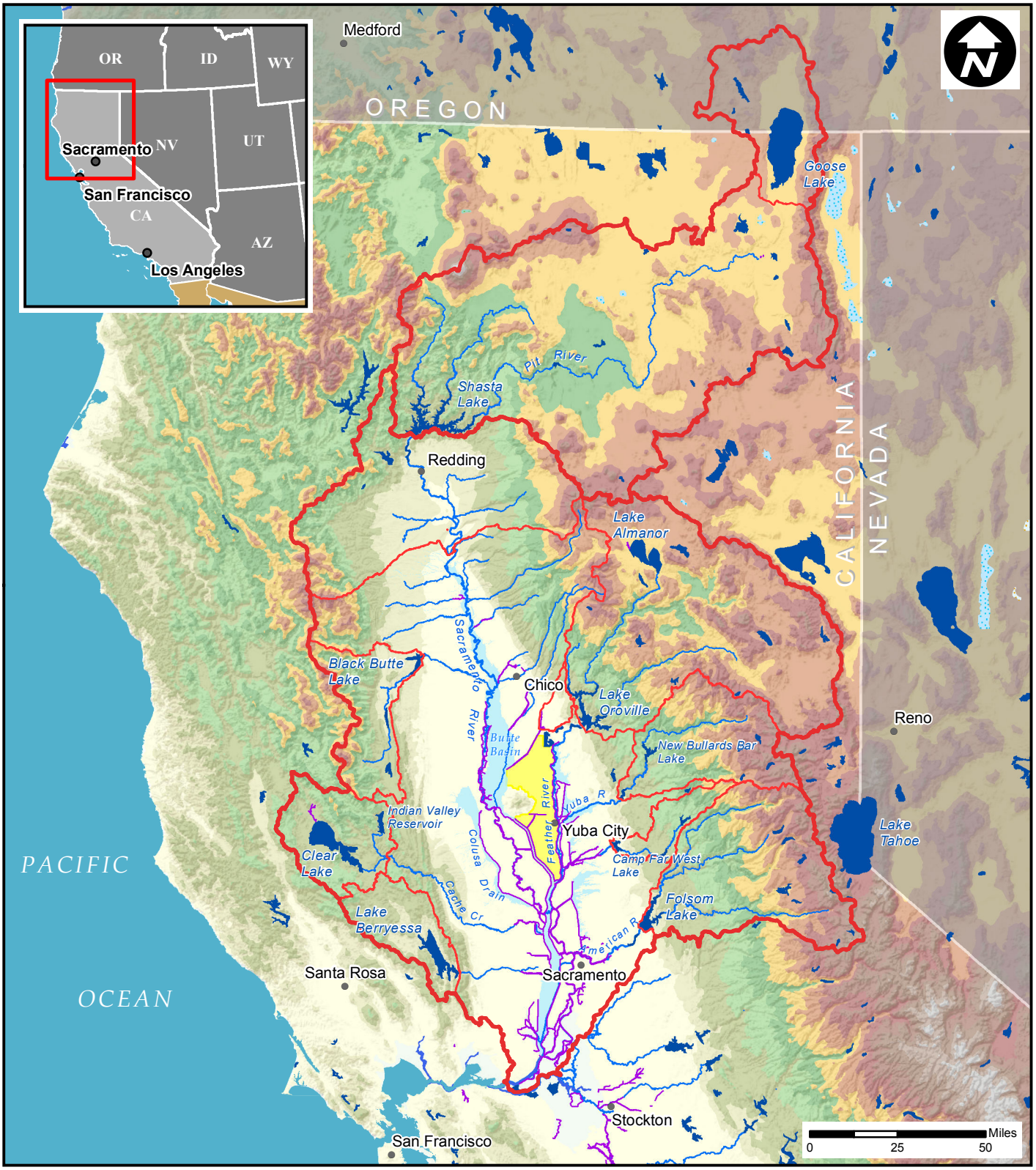


Legend

- Study Area Extent
- Sacramento Basin
- Watershed Boundaries
- Designated Floodways
- Lake or Reservoir
- River or Stream
- Federal Levees
- City

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

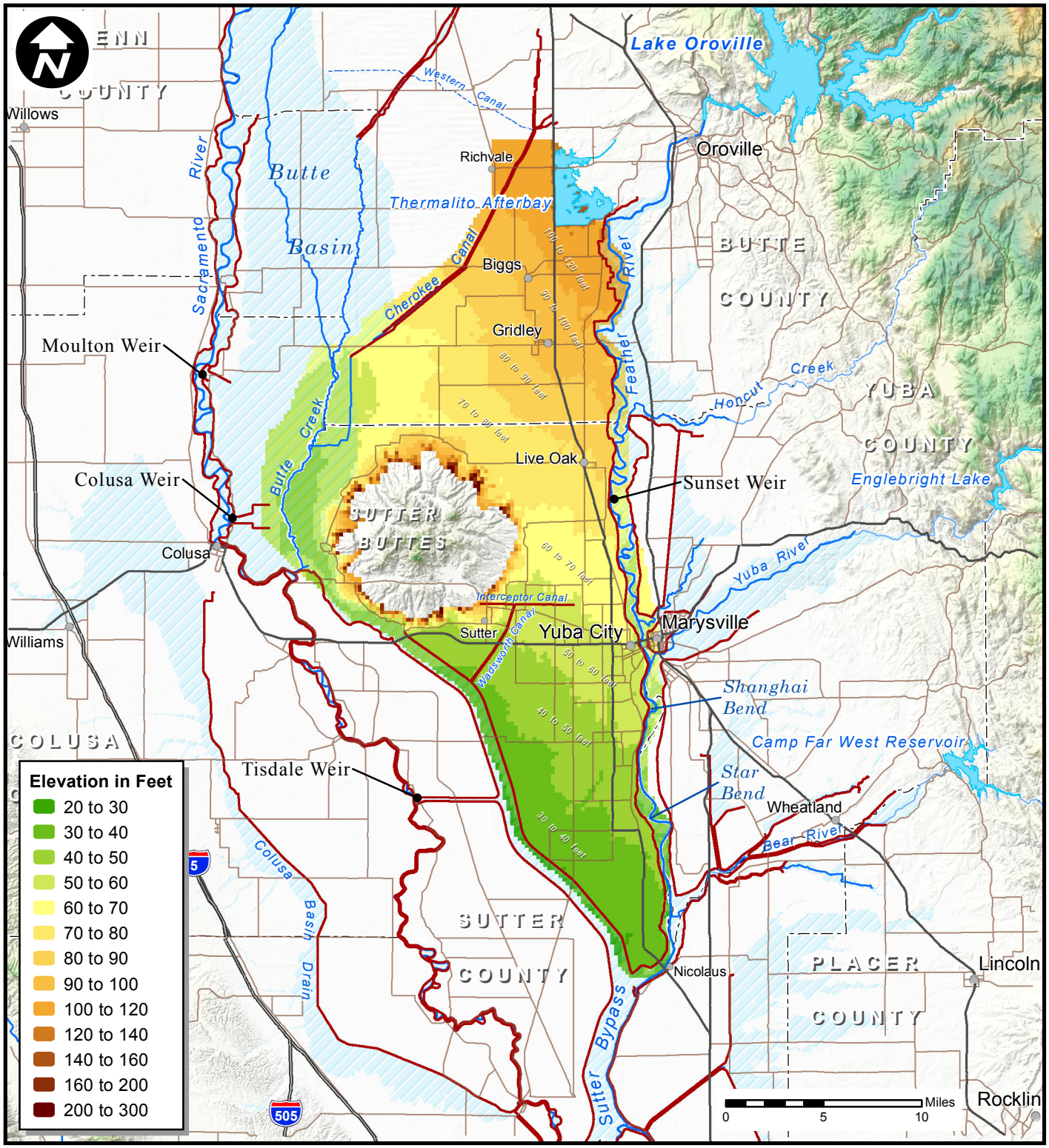
SACRAMENTO RIVER WATERSHED

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

OCT 2012

PLATE 1



Legend

- Designated Floodways
- Federal Levee
- Lake or Reservoir
- County Boundary
- River or Stream
- City or Town

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

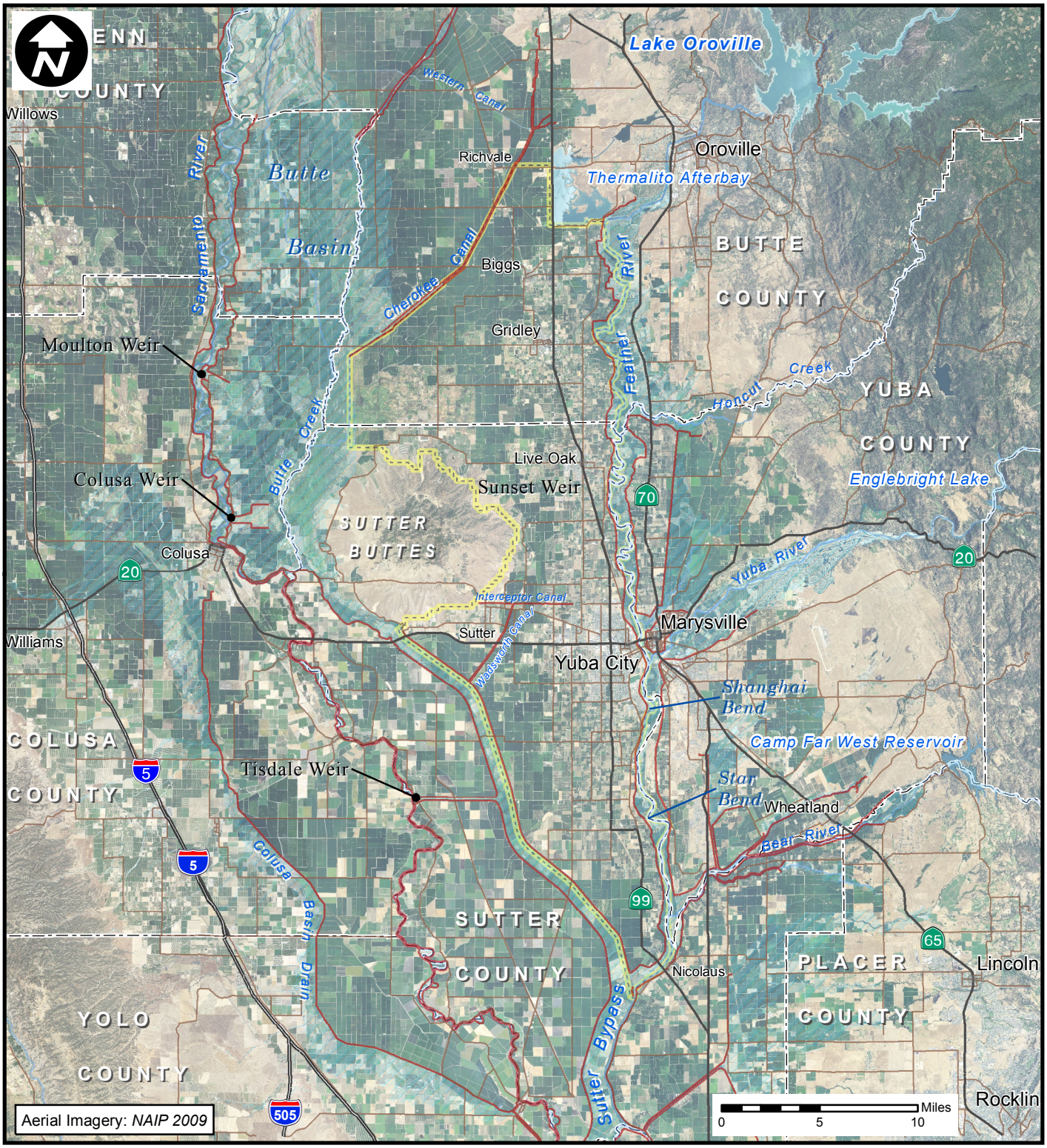
TOPOGRAPHY

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

OCT 2012

PLATE 2



Legend

- Study Area Extent
- Designated Floodways
- Lake or Reservoir
- River or Stream
- Federal Levee
- County Boundary
- City or Town

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

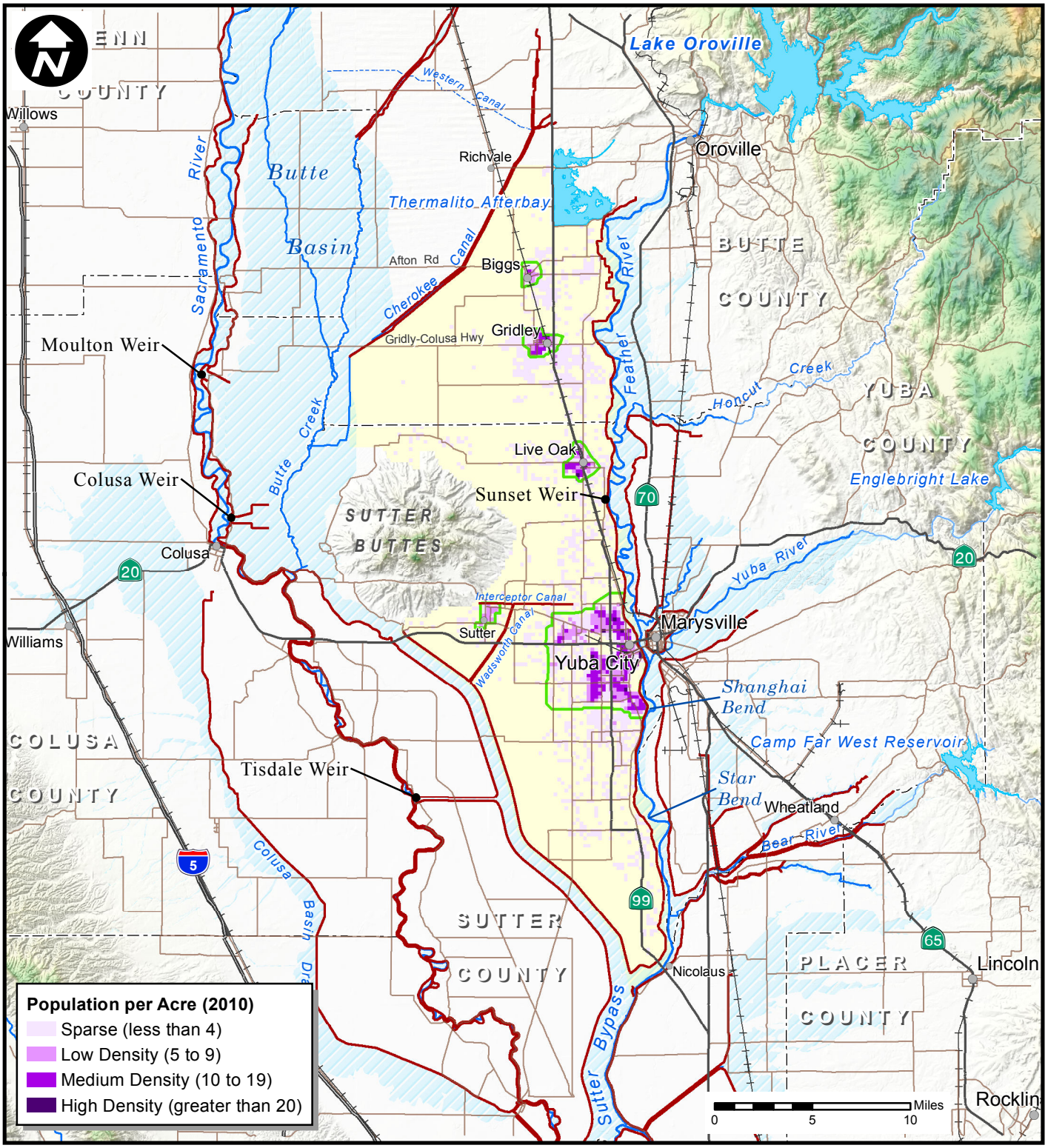
AERIAL IMAGERY

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

OCT 2012

PLATE 3



Legend

- Economic Evaluation Area
- Study Area Extent
- Designated Floodways
- Lake or Reservoir
- River or Stream
- Federal Levee
- Railroad
- County Boundary
- City or Town

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

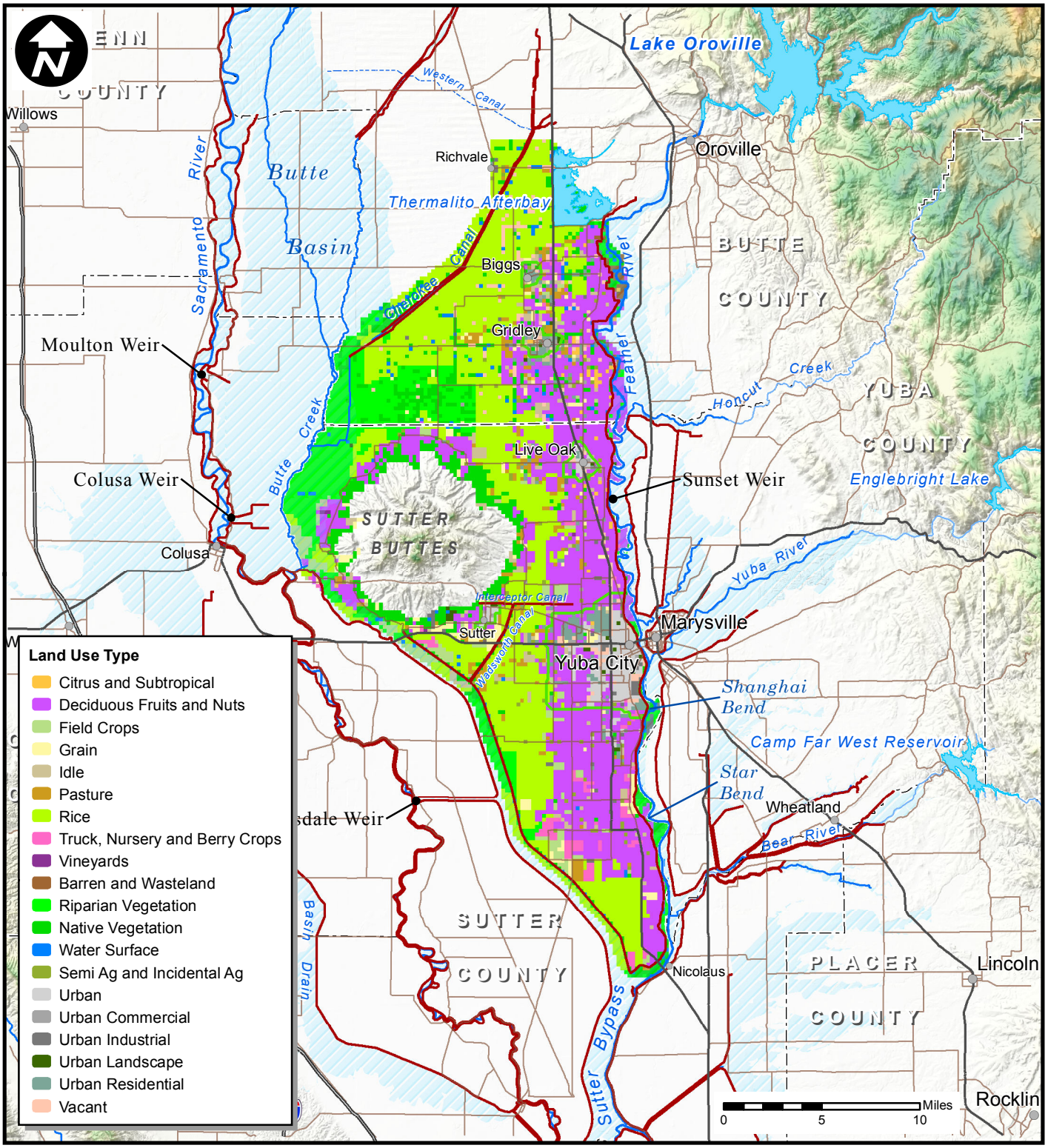
POPULATION DENSITY

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

OCT 2012

PLATE 4



Legend

- Designated Floodways
- Federal Levee
- Lake or Reservoir
- County Boundary
- River or Stream
- City or Town

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

LAND USE

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

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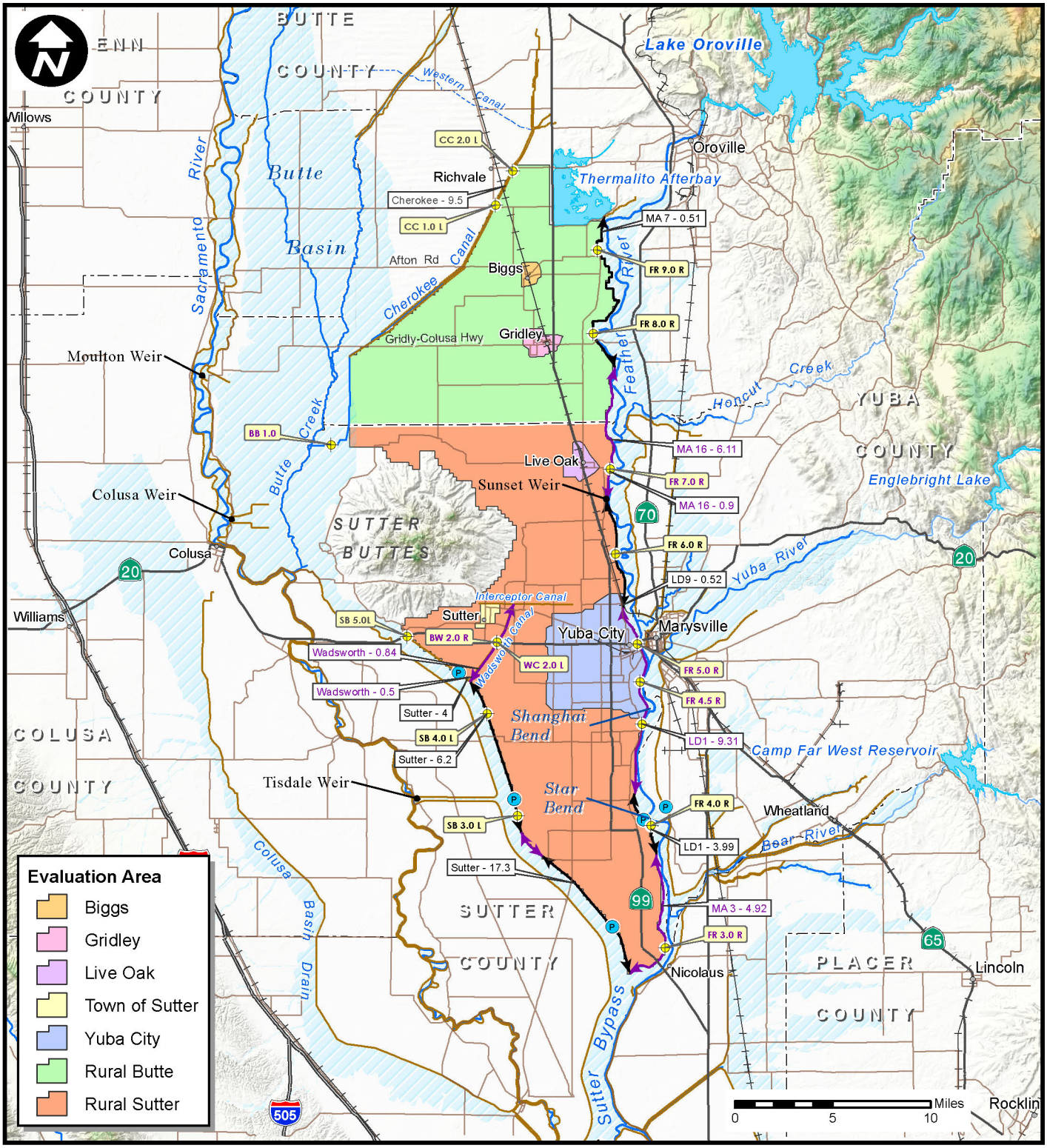
PLATE 5



Legend

- Geotechnical Levee Reach
- Federal Levee
- Breach Simulation Site
- Geotechnical Index Point
- Pump Station
- City or Town
- Designated Floodways
- Lake or Reservoir
- River or Stream
- Railroad
- County Boundary

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

ECONOMIC IMPACT AREAS

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

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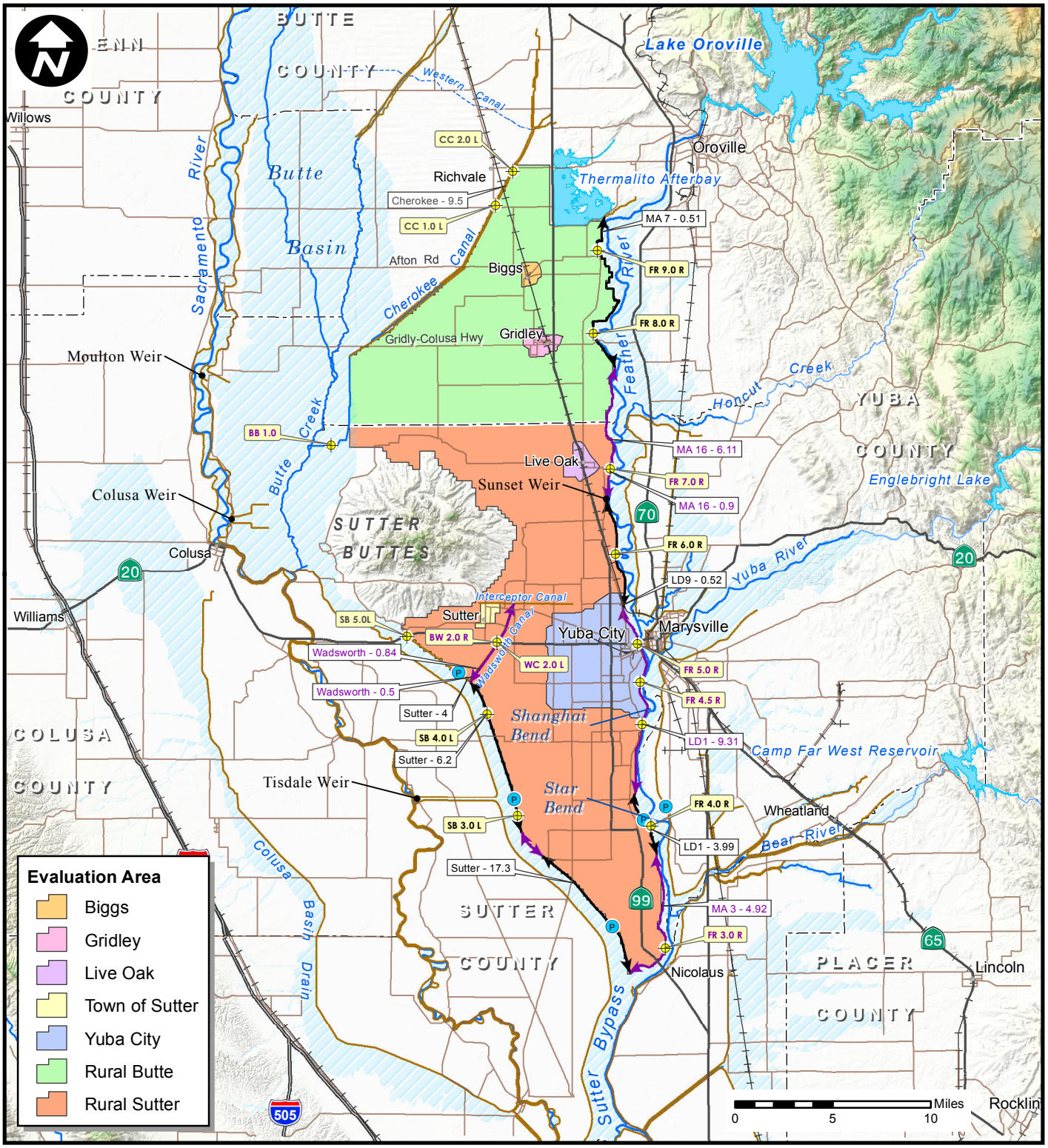
PLATE 6



Legend

- Geotechnical Levee Reach
- Federal Levee
- Breach Simulation Site
- Geotechnical Index Point
- Pump Station
- City or Town
- Designated Floodways
- Lake or Reservoir
- River or Stream
- Railroad
- County Boundary

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

ECONOMIC IMPACT AREAS

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

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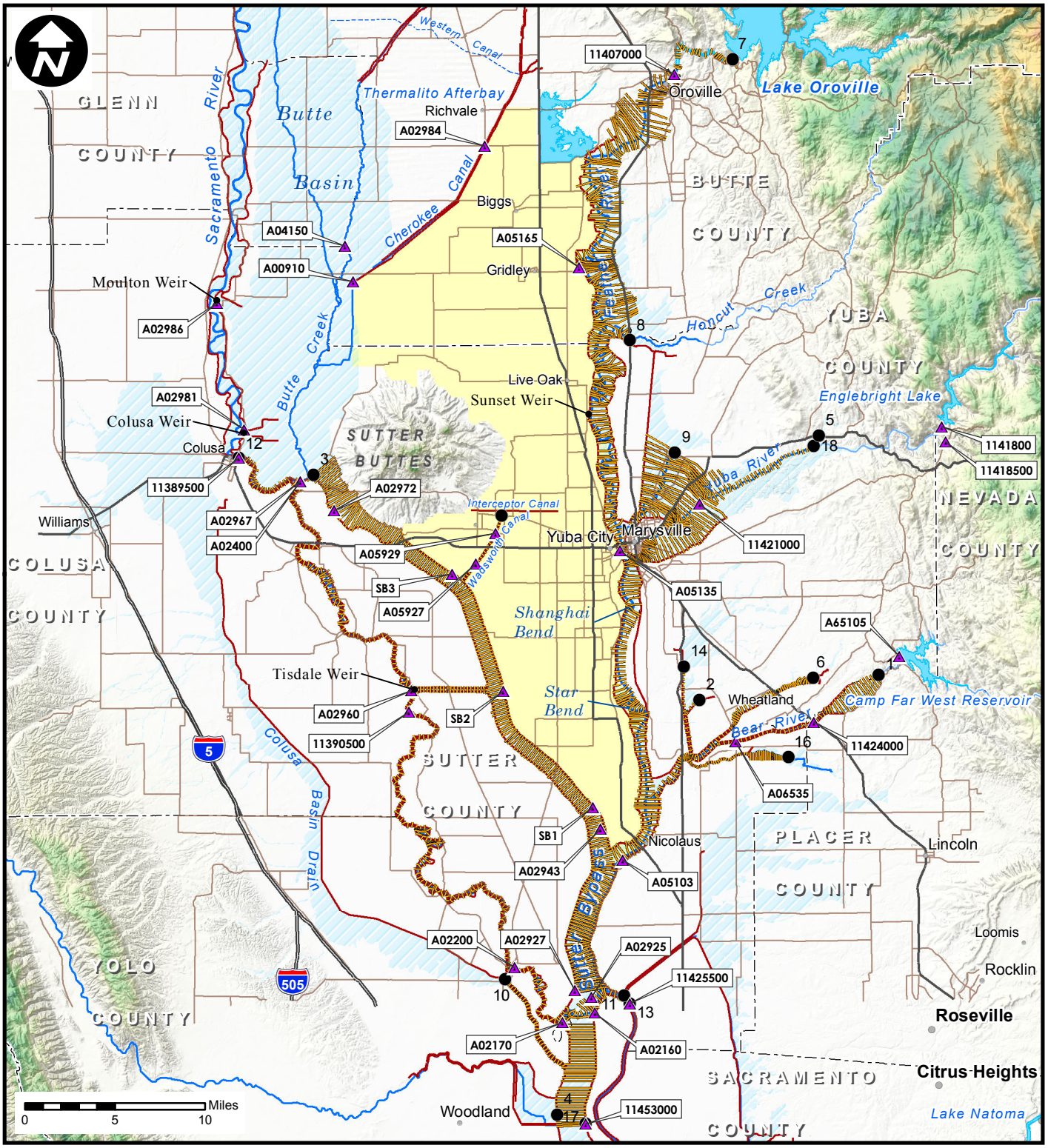
PLATE 6



Legend

- Stream Gage
- Model Boundaries
- Model Cross Sectios
- Federal Levee
- Study Area Extent
- Designated Floodways

NOTE: See Table 1 and 2 for Model Boundary Name

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

HEC-RAS HYDRAULIC MODEL BOUNDARY CONDITIONS AND STREAM GAGES

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

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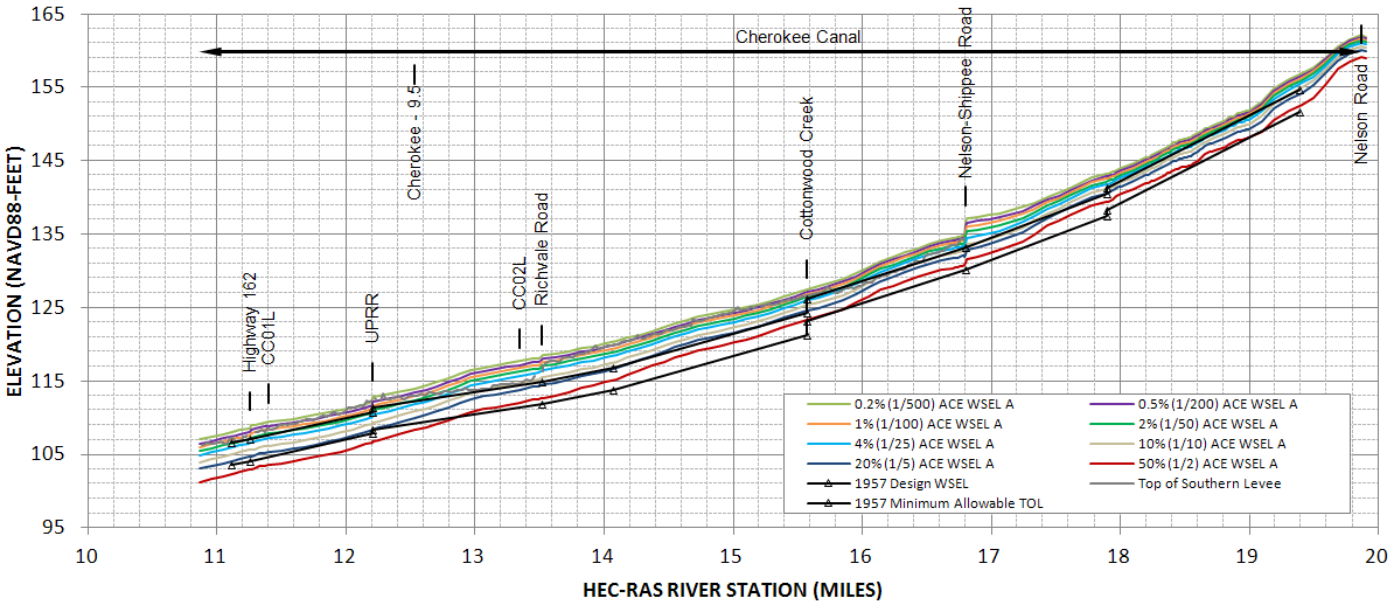
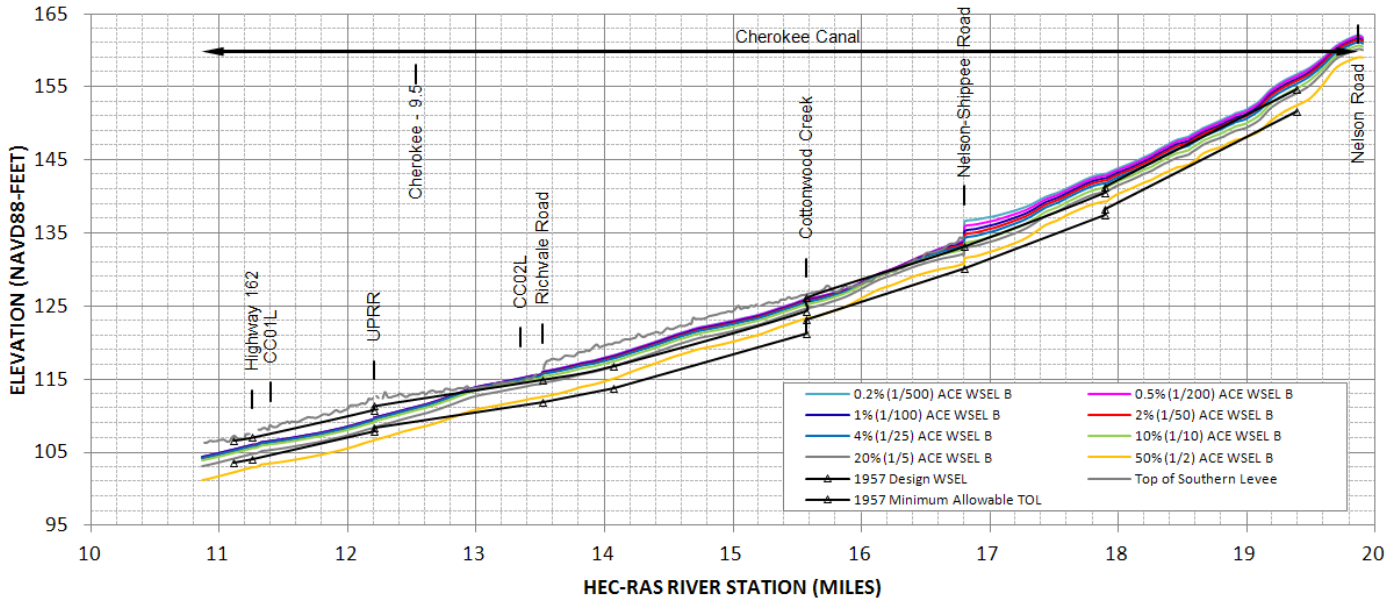
PLATE 7

Water Surface Profile A



Water Surface Profile B



Notes:

Water Surface Profile A assumes infinite levee height, no overtopping.

Water Surface Profile B assumes overtopping only, no failure.

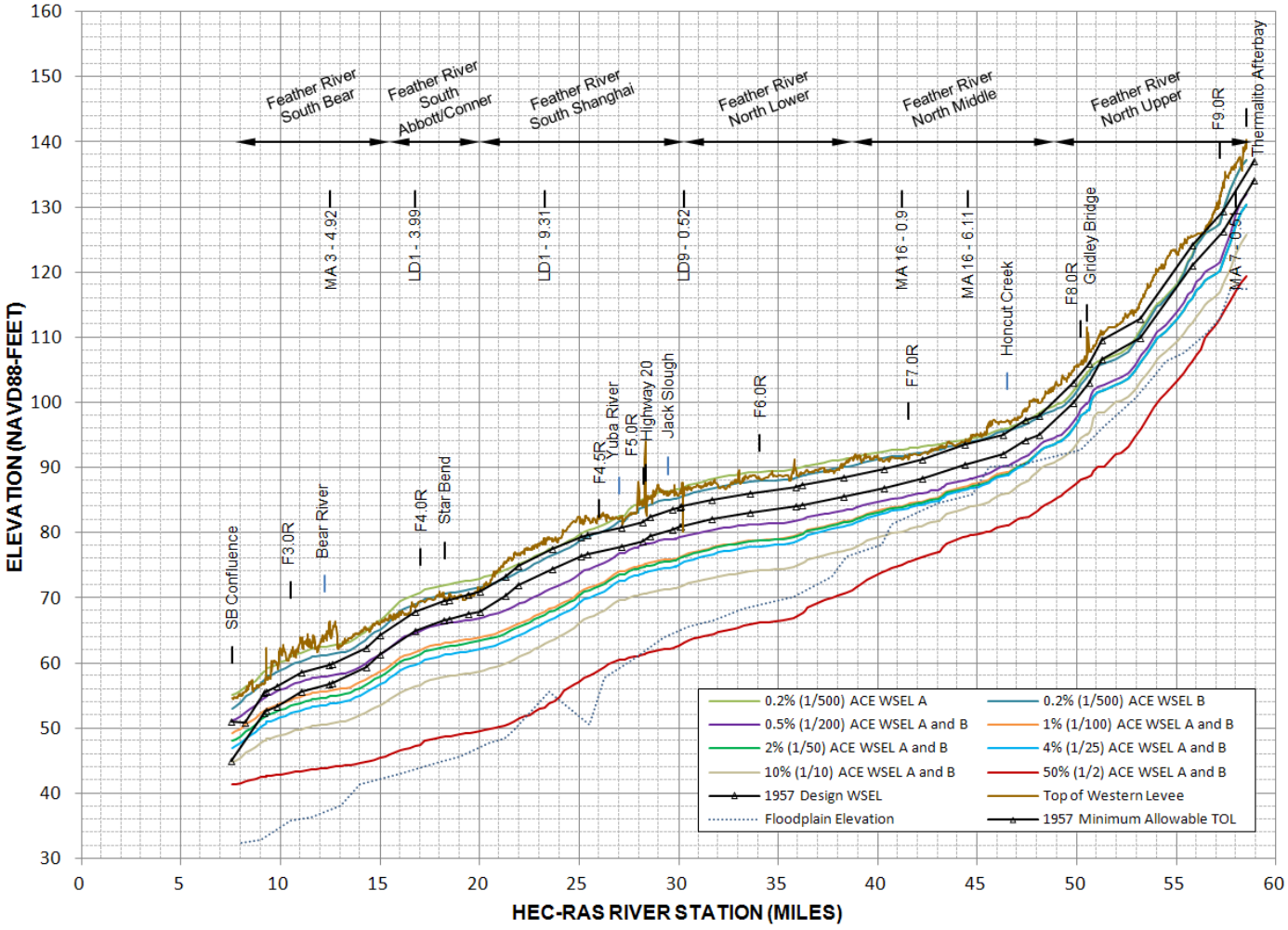
WSEL = Water Surface Elevation

Source:

SUTTER BASIN FEASBILITY STUDY
SUTTER BASIN, CALIFORNIA

CHEROKEE CANAL
WATER SURFACE PROFILES

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT



Notes:

Water Surface Profile A assumes infinite height levee, no overtopping.

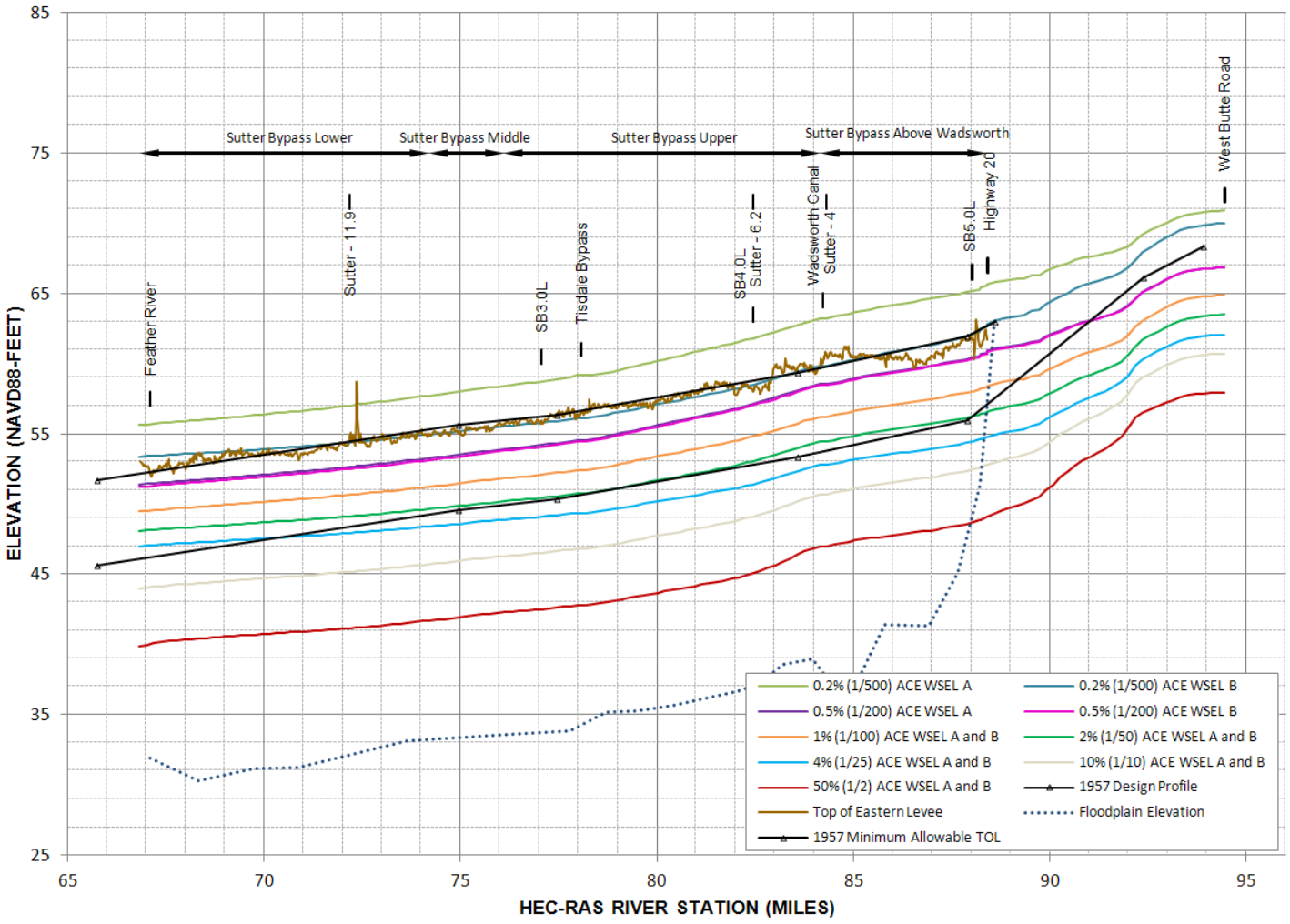
Water Surface Profile B assumes overtopping, no failure

WSEL = Water Surface Elevation

SUTTER BASIN FEASBILITY STUDY
SUTTER BASIN, CALIFORNIA

FEATHER RIVER WATER SURFACE PROFILES

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT



Note:

Water Surface Profile A assumes infinite levee height, no overtopping.

Water Surface Elevation B assumes overtopping only, no failure

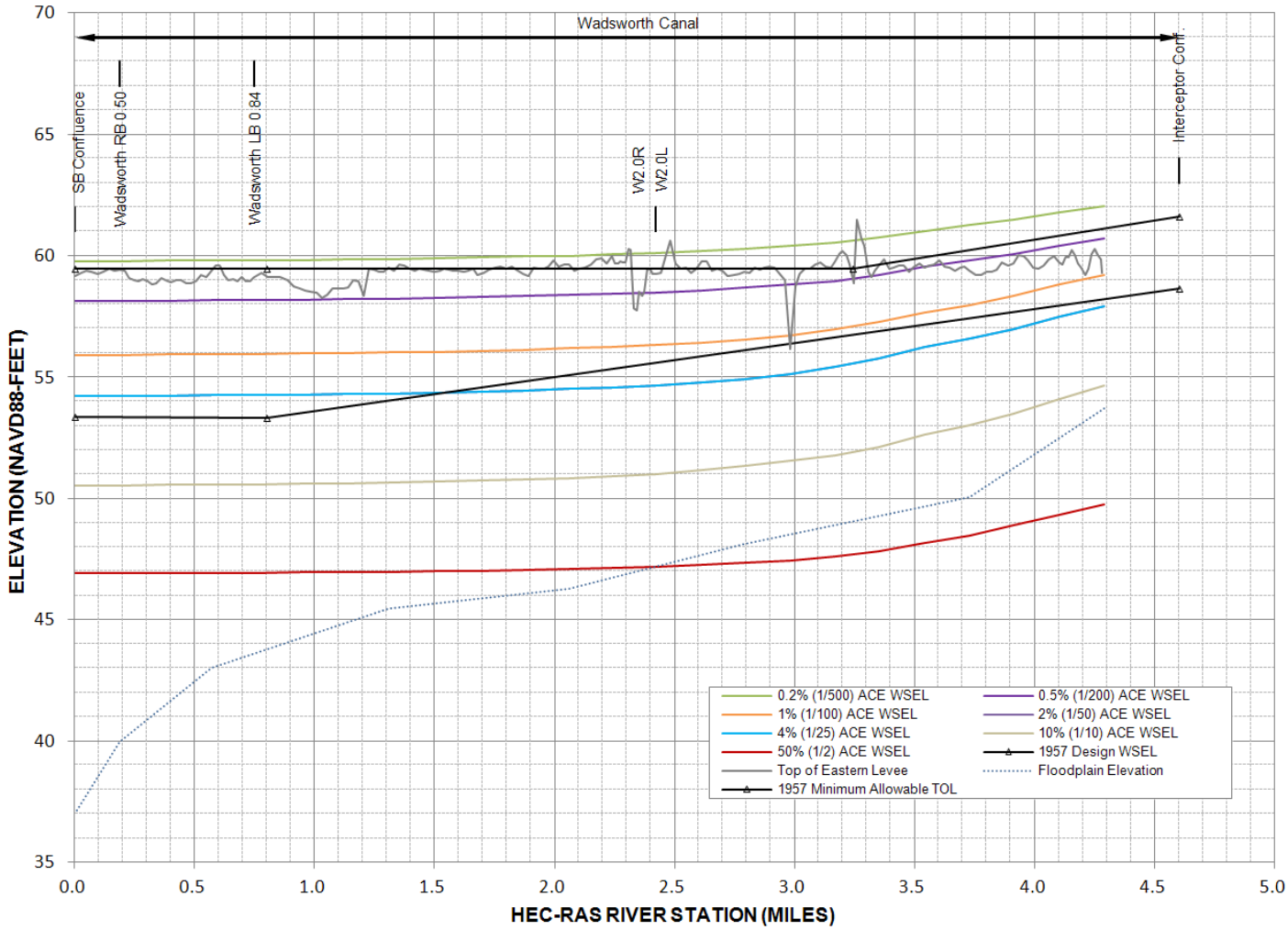
WSEL = Water Surface Elevation

Source:

SUTTER BASIN FEASBILITY STUDY
SUTTER BASIN, CALIFORNIA

SUTTER BYPASS WATER SURFACE PROFILES

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT



Notes:

Water Surface Profiles assume infinite height levee, no overtopping.

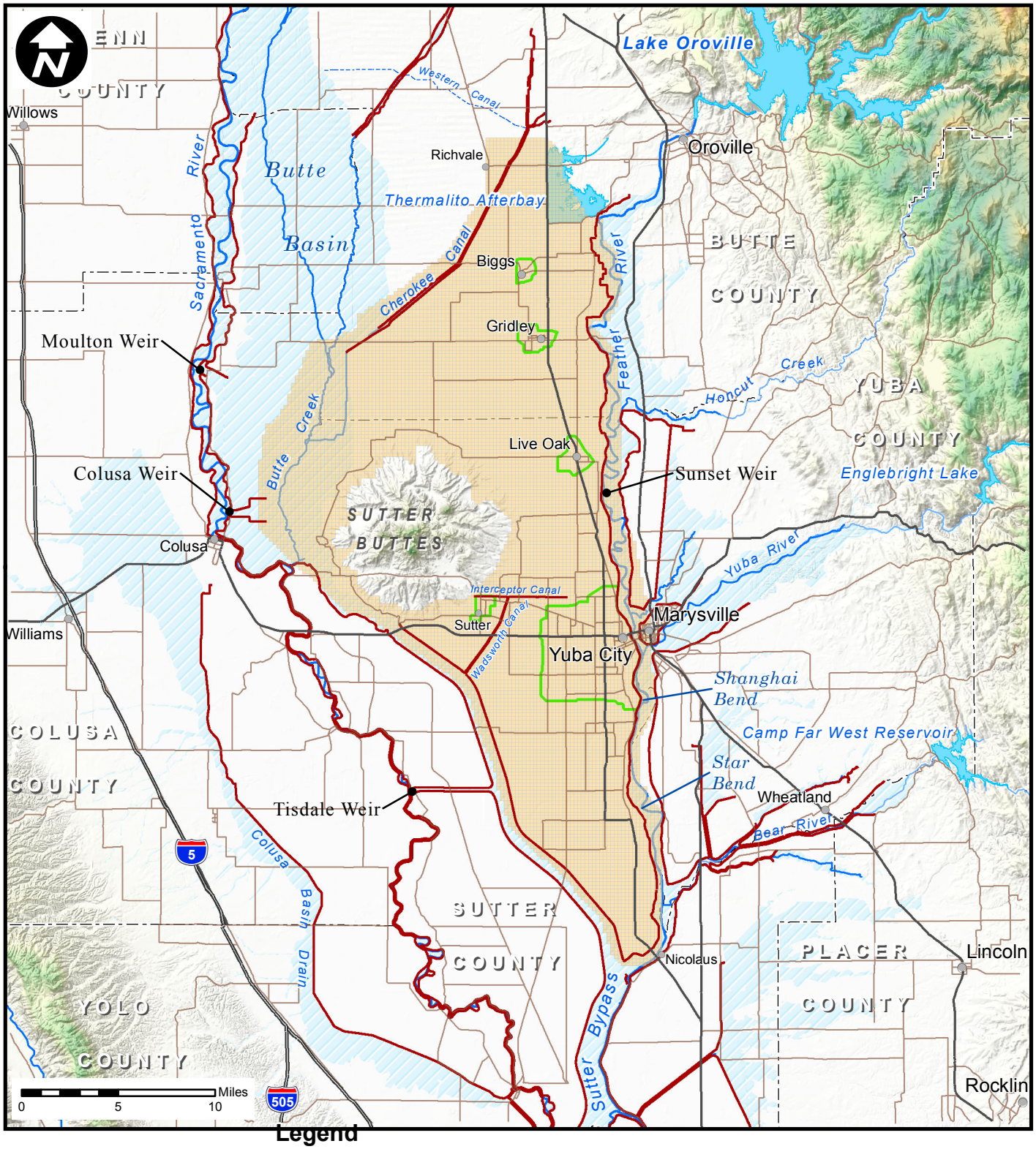
Overtopping, no failure was not created for Wadsworth Canal.

WSEL = Water Surface Elevation

SUTTER BASIN FEASBILITY STUDY
SUTTER BASIN, CALIFORNIA

WADSWORTH CANAL WATER SURFACE PROFILES

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT



Legend

- FLO2D Grid
- Designated Floodways
- Lake or Reservoir
- Economic Evaluation Area
- River or Stream
- Federal Levee
- County Boundary
- City or Town

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

FLO2D MODEL GRID

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

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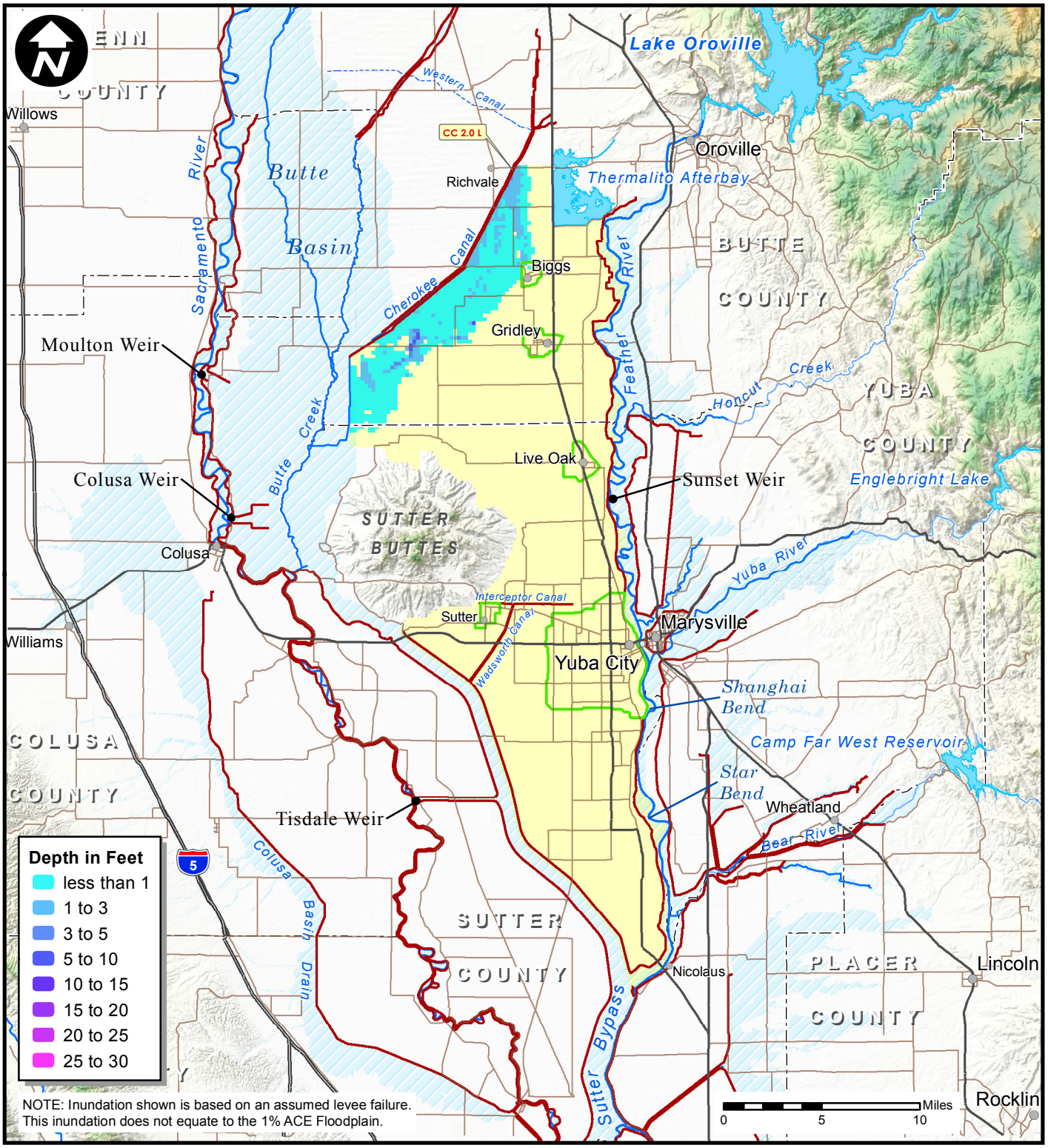
PLATE 12



Legend

- Breach Index Point
- Designated Floodways
- Lake or Reservoir
- River or Stream
- Study Area Extent
- Federal Levee
- County Boundary
- City or Town

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

MODELED BREACH INUNDATION
CC 2.0 L INDEX POINT
1% ACE EVENT

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SACRAMENTO DISTRICT

Prepared by Jim Mars

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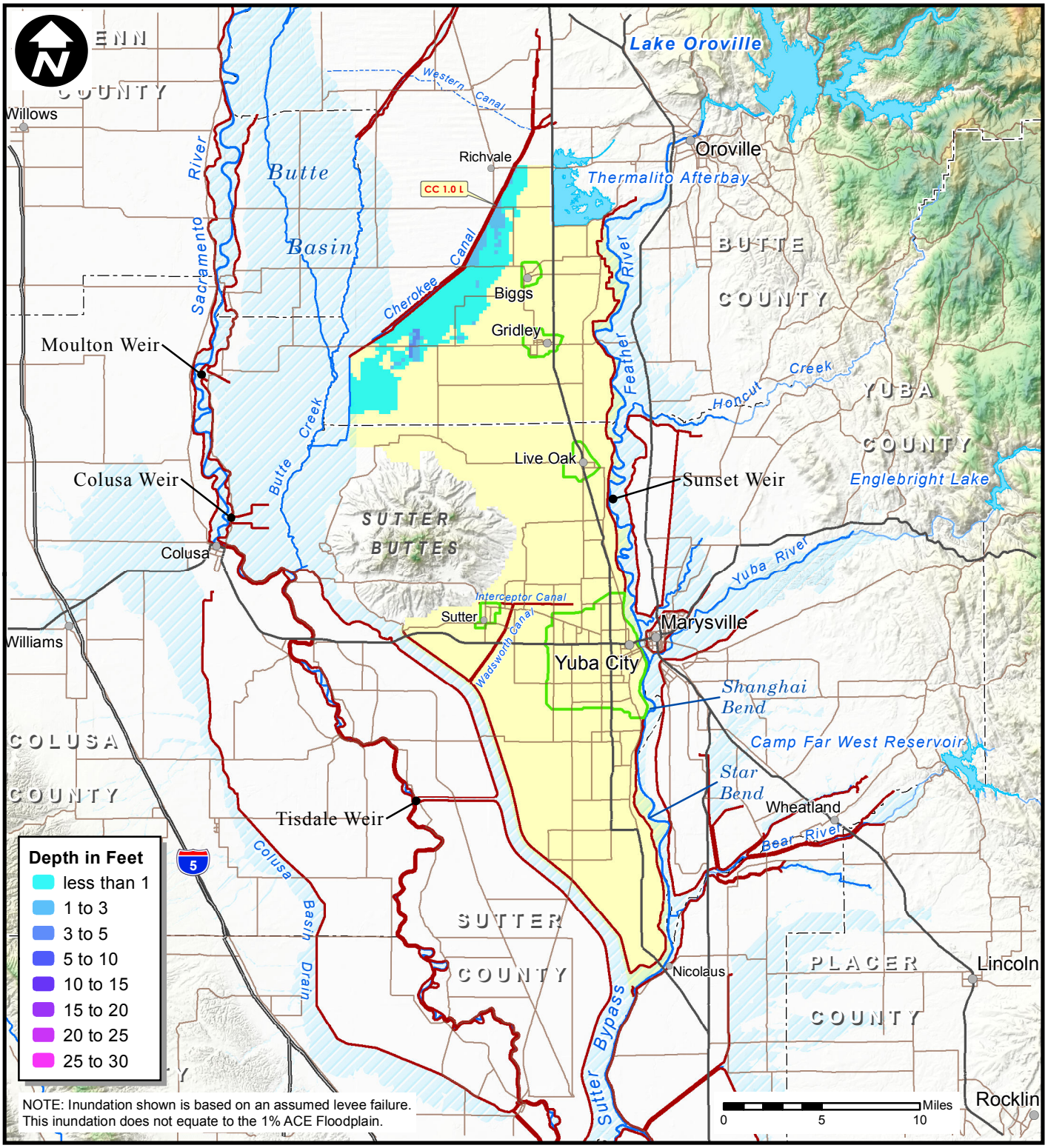
PLATE 13



Legend

- Breach Index Point
- Designated Floodways
- Lake or Reservoir
- River or Stream
- Study Area Extent
- Federal Levee
- County Boundary
- City or Town

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

MODELED BREACH INUNDATION
CC 1.0 L INDEX POINT
1% ACE EVENT

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SACRAMENTO DISTRICT

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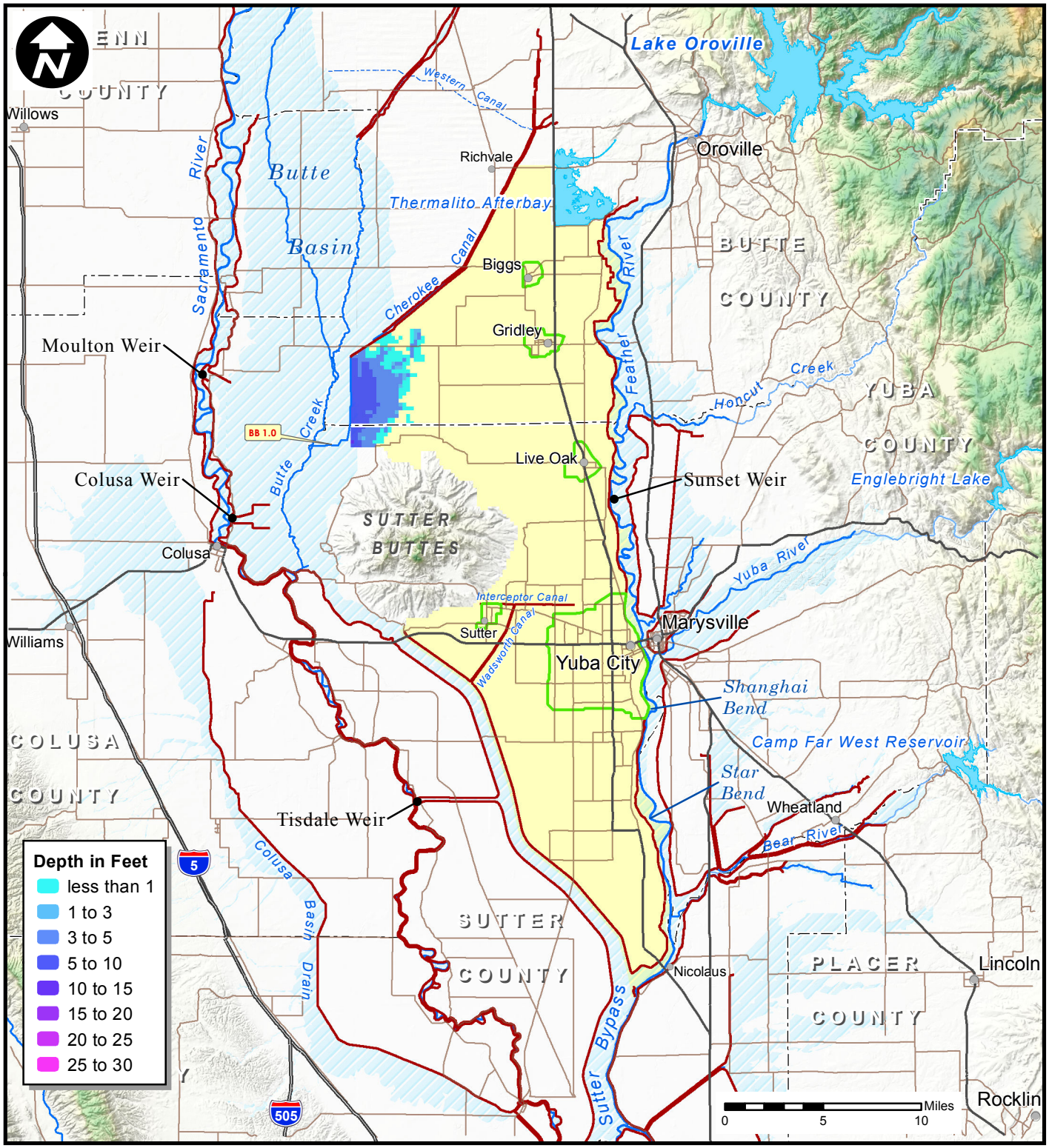
PLATE 14



Legend

- Flood Source Point
- Designated Floodways
- Lake or Reservoir
- River or Stream
- Study Area Extent
- Federal Levee
- County Boundary
- City or Town

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

MODELED INUNDATION
BB 1.0 INDEX POINT
1% ACE EVENT

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SACRAMENTO DISTRICT

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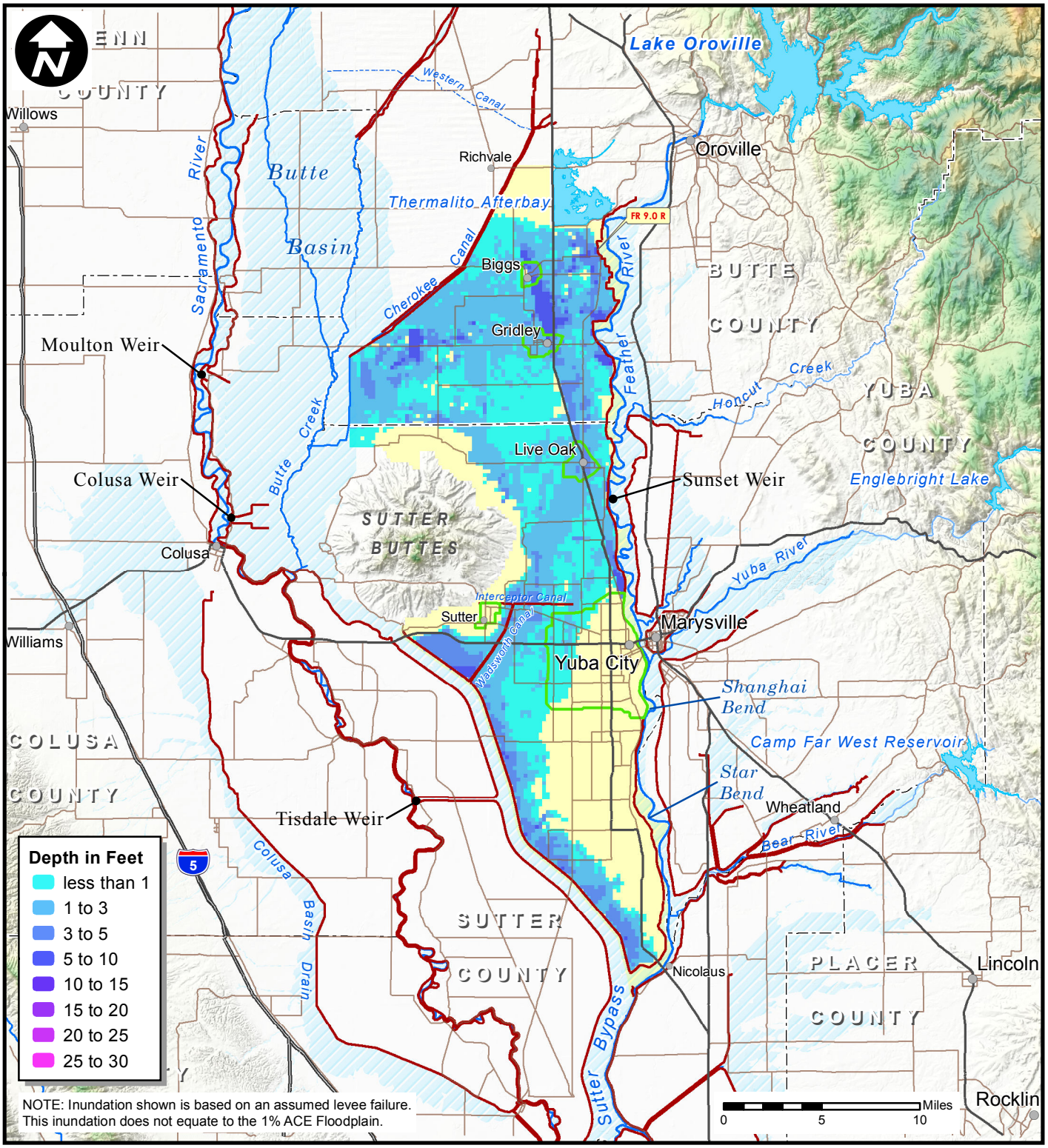
PLATE 15



Legend

- Breach Index Point
- Designated Floodways
- Lake or Reservoir
- River or Stream
- Study Area Extent
- Federal Levee
- County Boundary
- City or Town

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

MODELED BREACH INUNDATION
FR 9.0 R INDEX POINT
1% ACE EVENT

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SACRAMENTO DISTRICT

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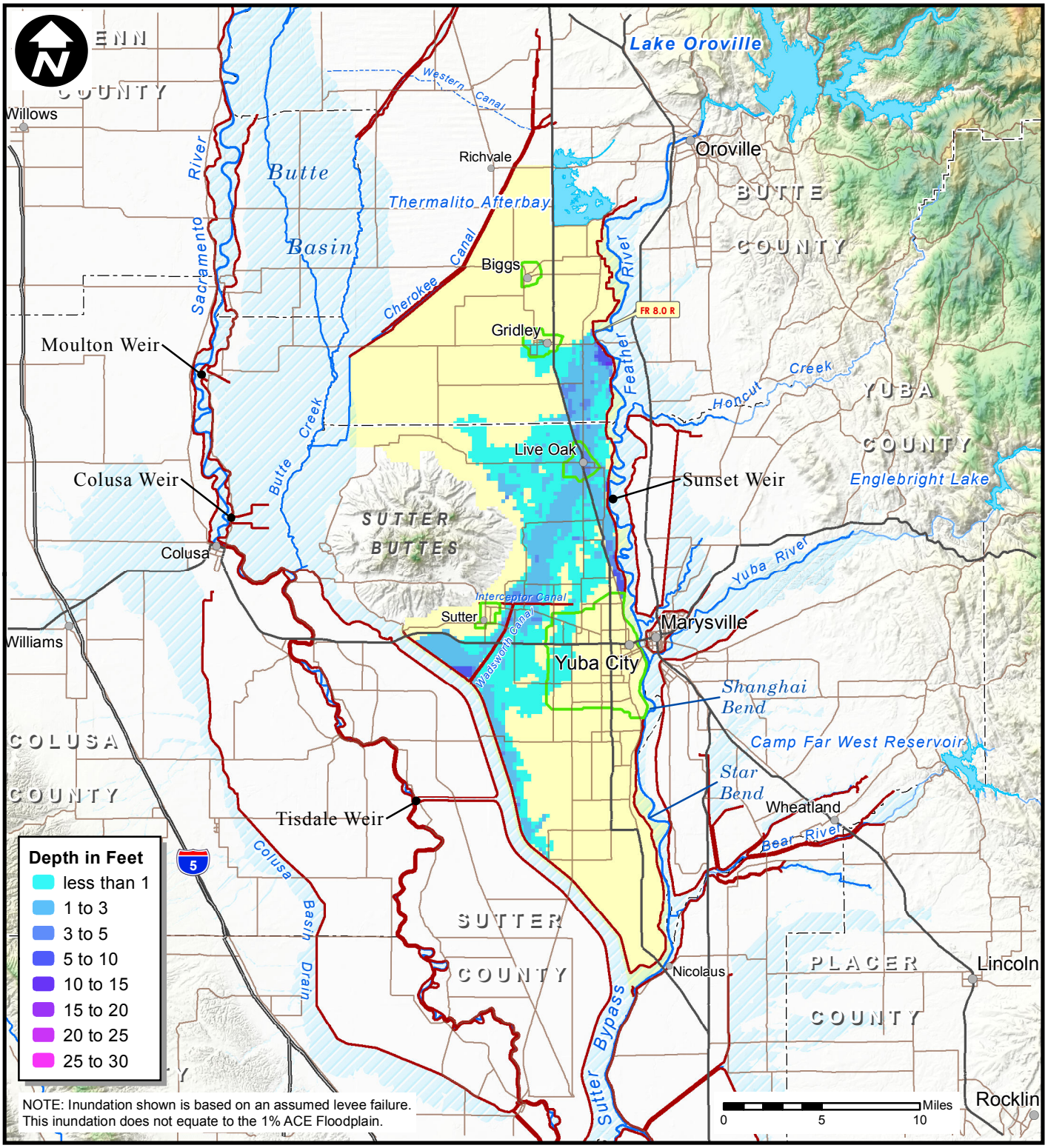
PLATE 16



Legend

- Breach Index Point
- Designated Floodways
- Lake or Reservoir
- River or Stream
- Study Area Extent
- Federal Levee
- County Boundary
- City or Town

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

MODELED BREACH INUNDATION
FR 8.0 R INDEX POINT
1% ACE EVENT

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SACRAMENTO DISTRICT

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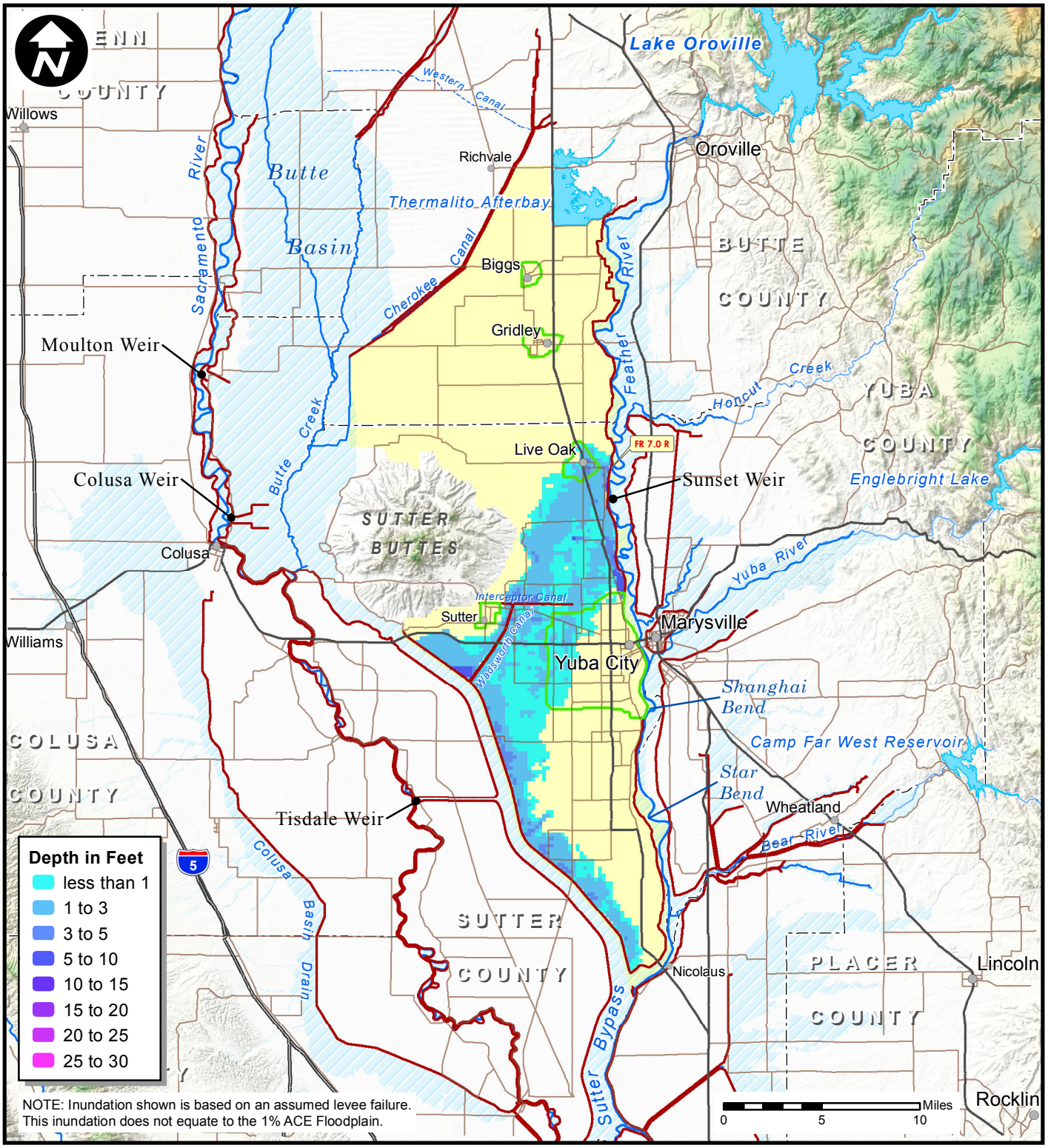
PLATE 17



Legend

- Breach Index Point
- Designated Floodways
- Lake or Reservoir
- River or Stream
- Study Area Extent
- Federal Levee
- County Boundary
- City or Town

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

MODELED BREACH INUNDATION
FR 7.0 R INDEX POINT
1% ACE EVENT

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

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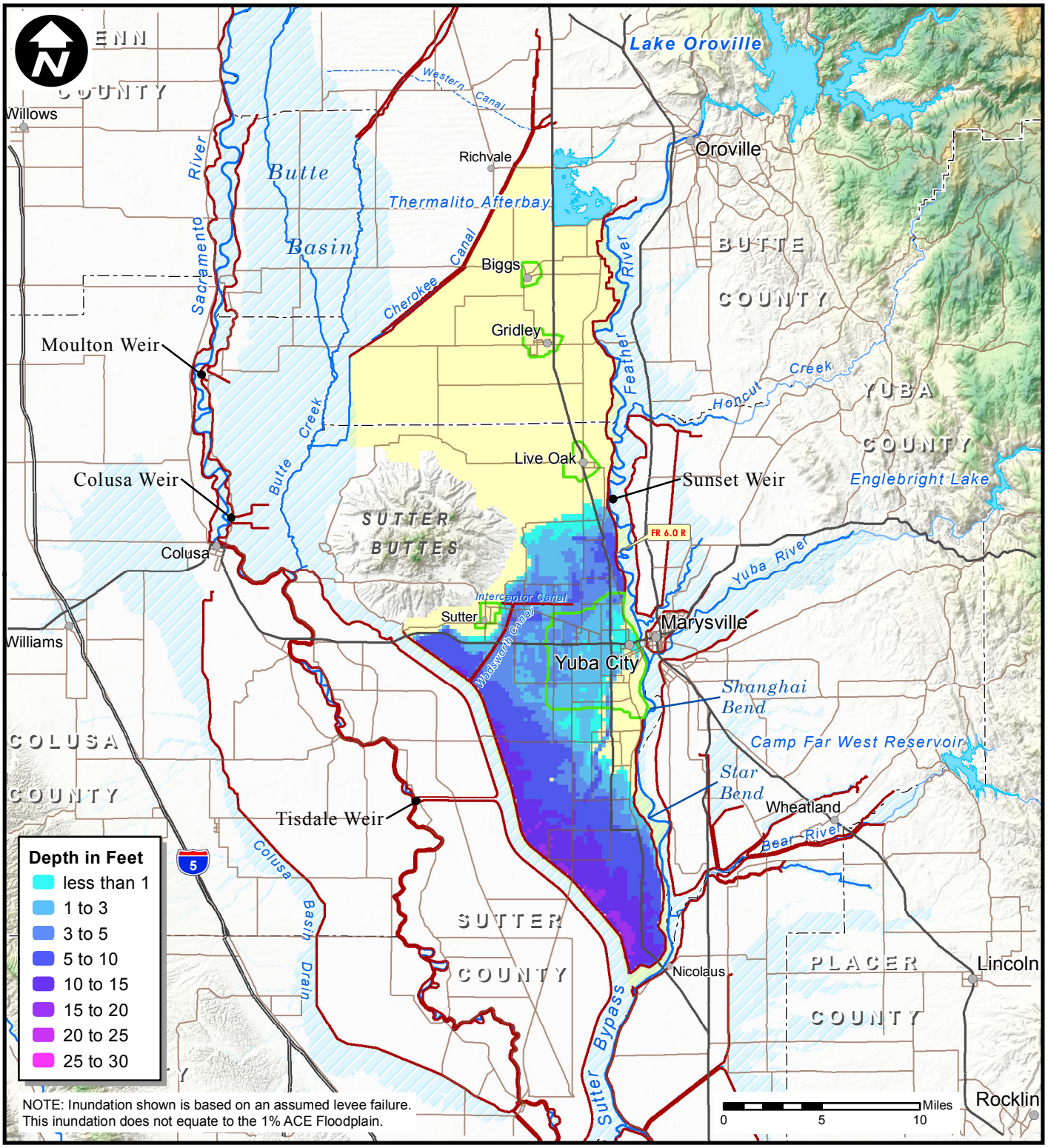
PLATE 18



Legend

- Breach Index Point
- Study Area Extent
- Designated Floodways
- Federal Levee
- Lake or Reservoir
- County Boundary
- River or Stream
- City or Town

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

MODELED BREACH INUNDATION
FR 6.0 R INDEX POINT
1% ACE EVENT

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SACRAMENTO DISTRICT

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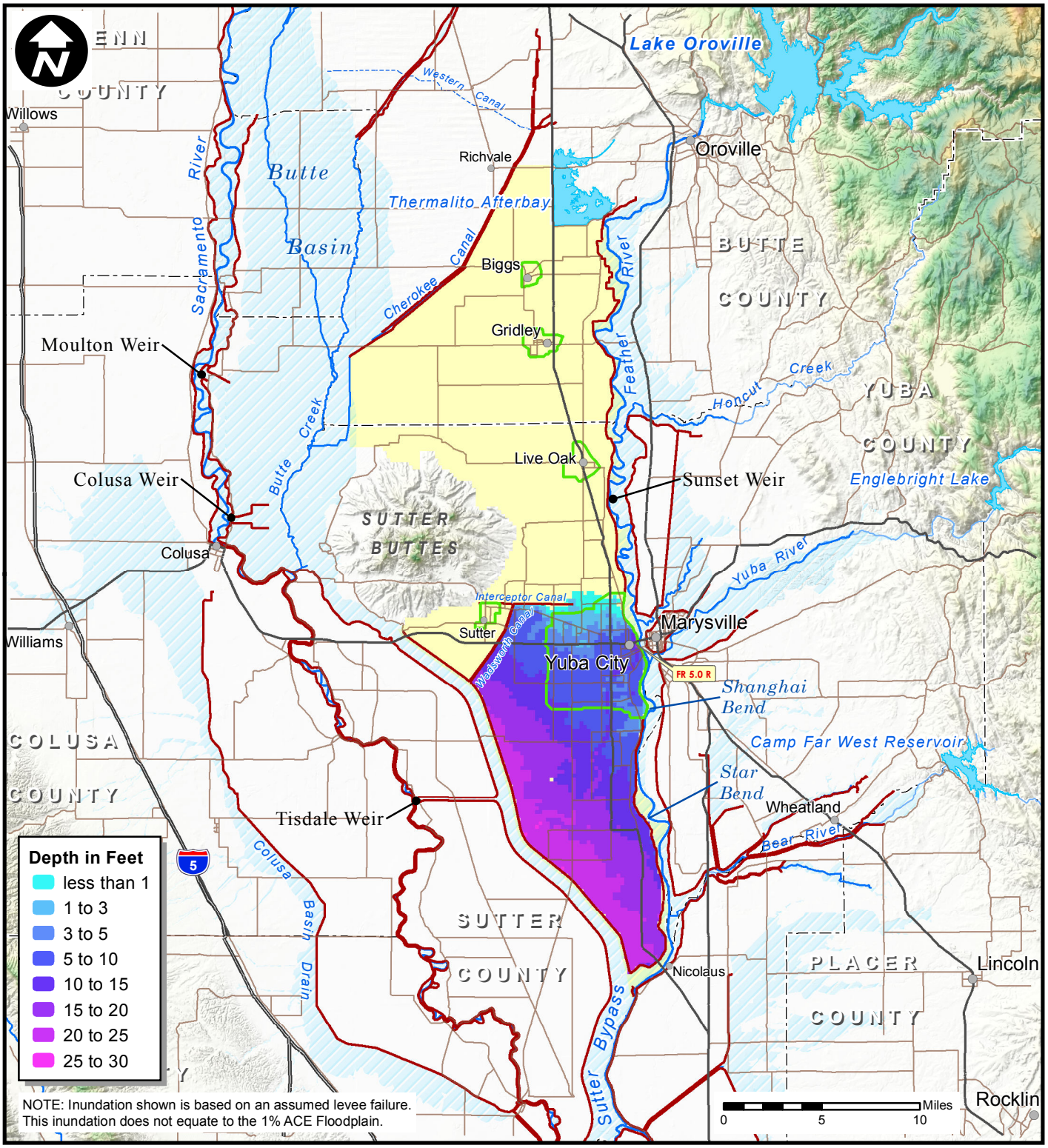
PLATE 19



Legend

- Breach Index Point
- Designated Floodways
- Lake or Reservoir
- River or Stream
- Study Area Extent
- Federal Levee
- County Boundary
- City or Town

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

MODELED BREACH INUNDATION
FR 5.0 R INDEX POINT
1% ACE EVENT

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SACRAMENTO DISTRICT

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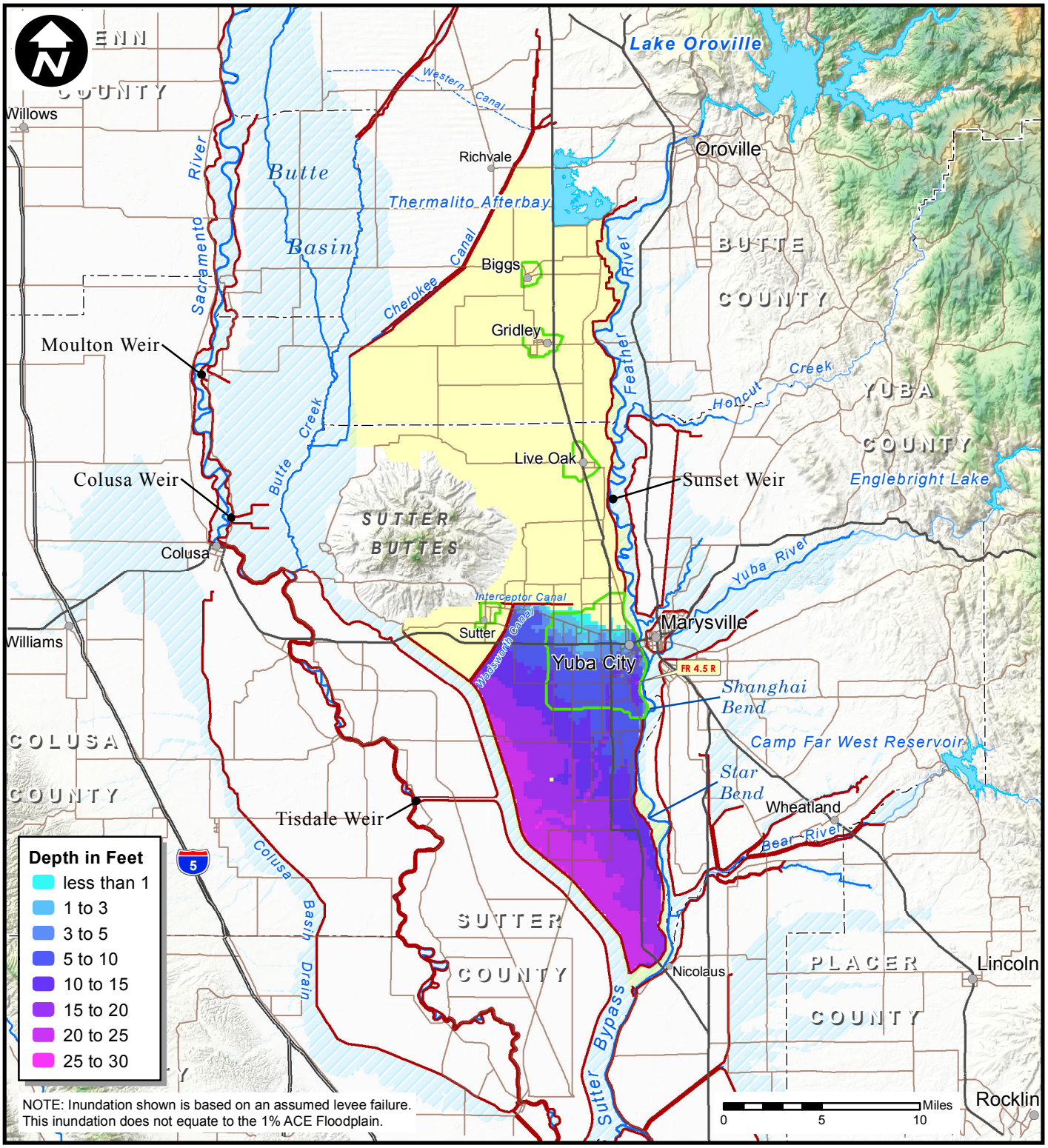
PLATE 20



Legend

- Breach Index Point
- Designated Floodways
- Lake or Reservoir
- River or Stream
- Study Area Extent
- Federal Levee
- County Boundary
- City or Town

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

MODELED BREACH INUNDATION
FR 4.5 R INDEX POINT
1% ACE EVENT

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

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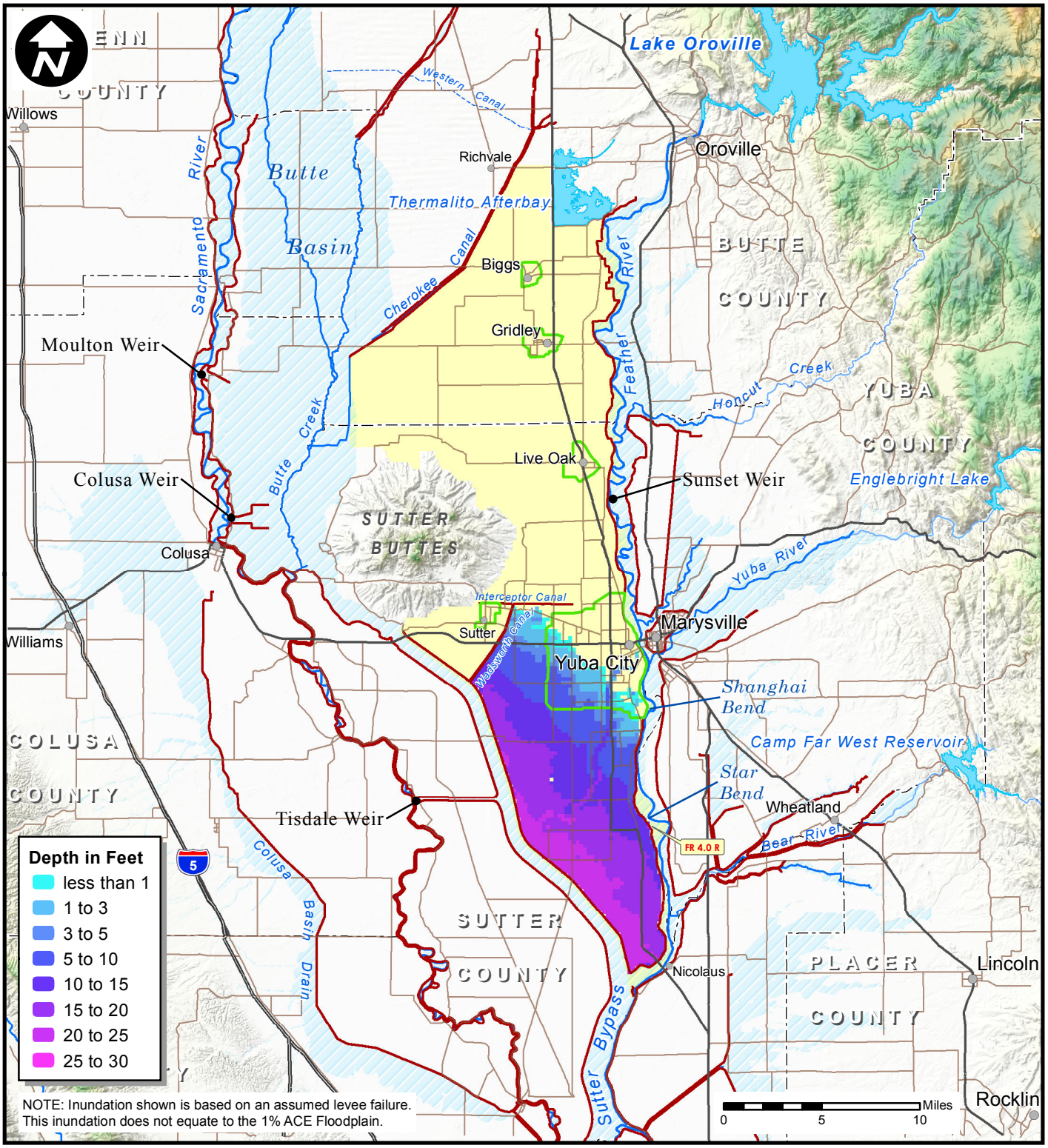
PLATE 21



Legend

- Breach Index Point
- Designated Floodways
- Lake or Reservoir
- River or Stream
- Study Area Extent
- Federal Levee
- County Boundary
- City or Town

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

MODELED BREACH INUNDATION
FR 4.0 R INDEX POINT
1% ACE EVENT

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

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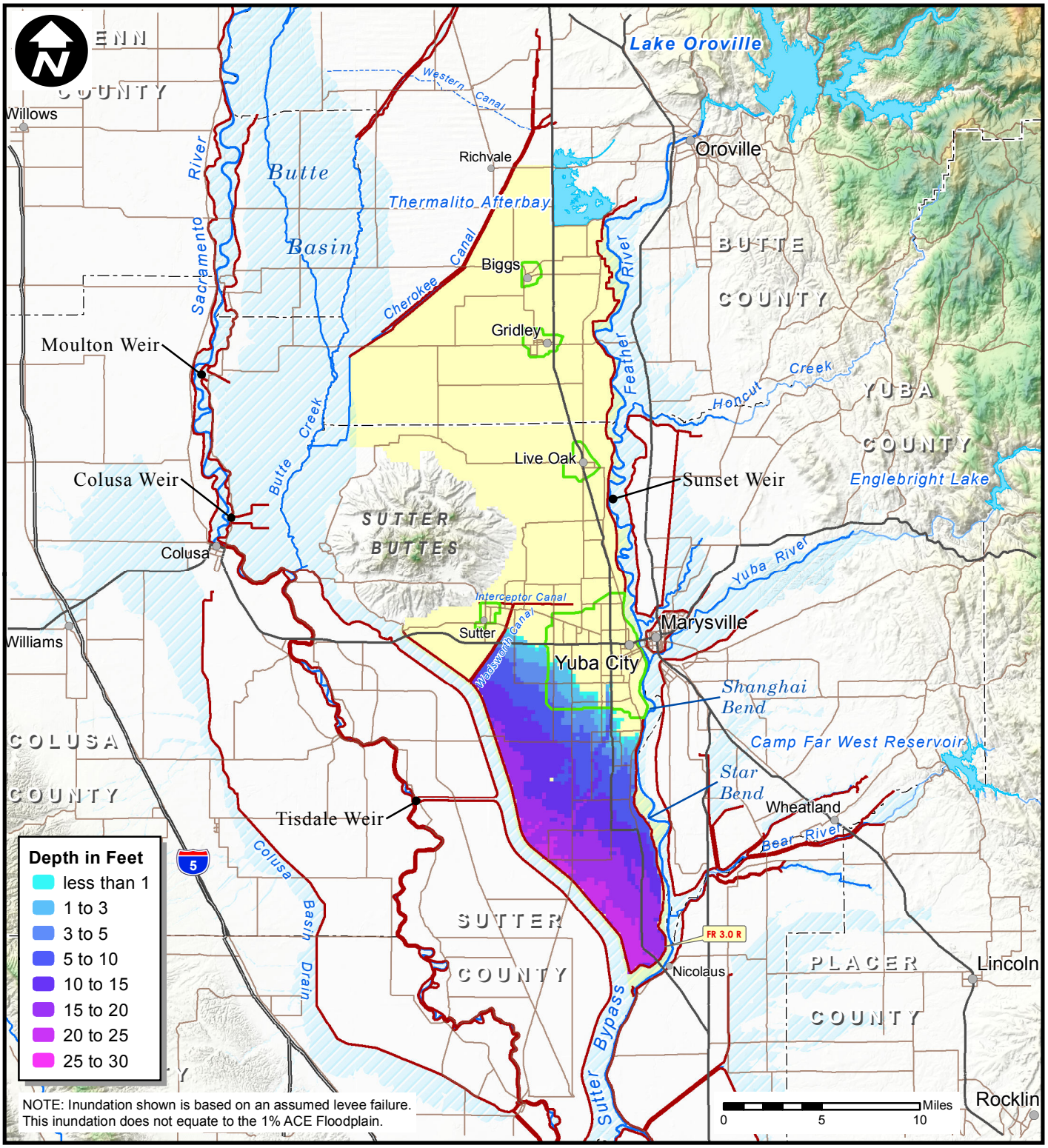
PLATE 22



Legend

- Breach Index Point
- Designated Floodways
- Lake or Reservoir
- River or Stream
- Study Area Extent
- Federal Levee
- County Boundary
- City or Town

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

MODELED BREACH INUNDATION
FR 3.0 R INDEX POINT
1% ACE EVENT

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

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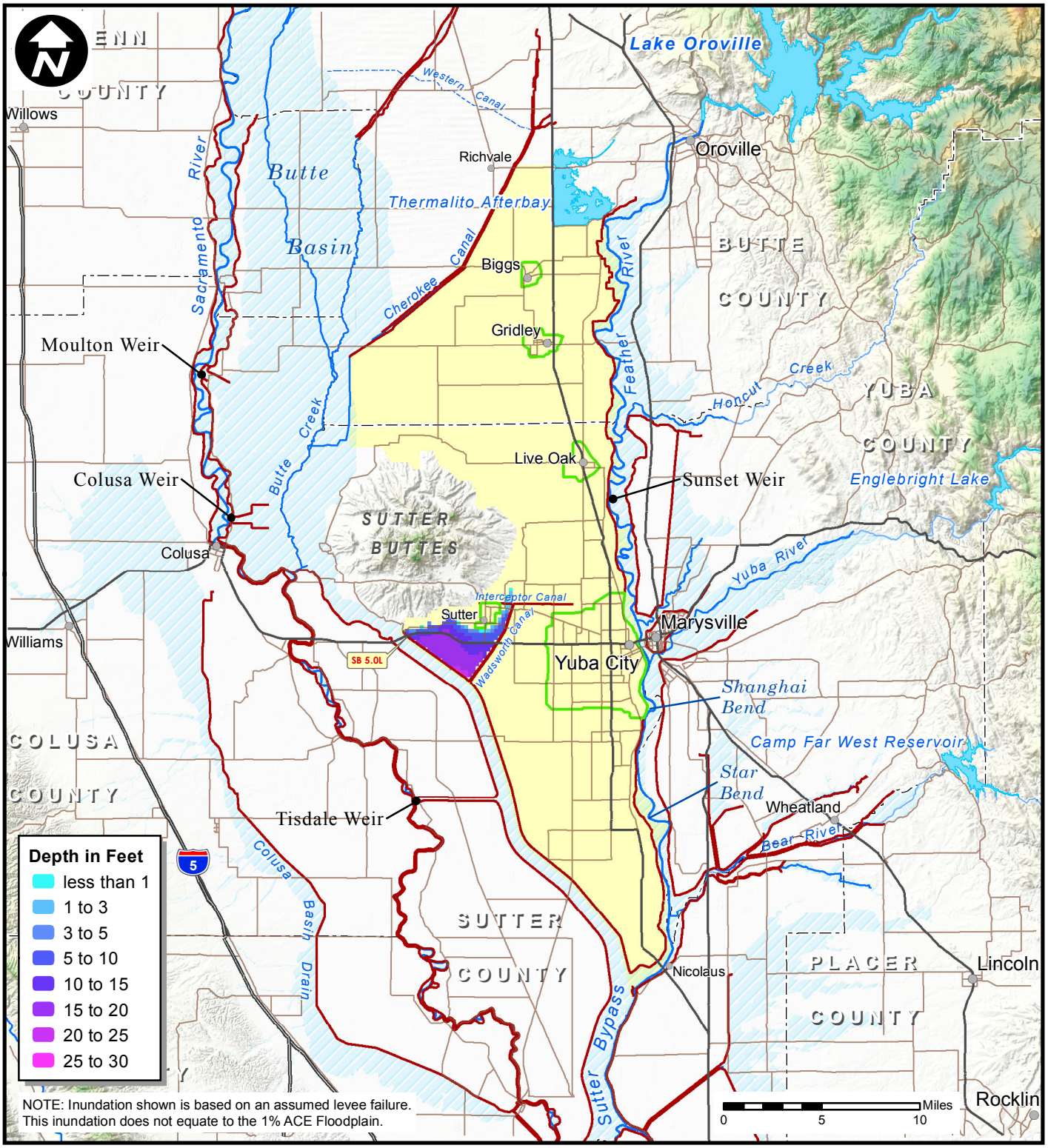
PLATE 23



Legend

- Breach Index Point
- Designated Floodways
- Lake or Reservoir
- River or Stream
- Study Area Extent
- Federal Levee
- County Boundary
- City or Town

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

MODELED BREACH INUNDATION
SB 5.0 L INDEX POINT
1% ACE EVENT

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

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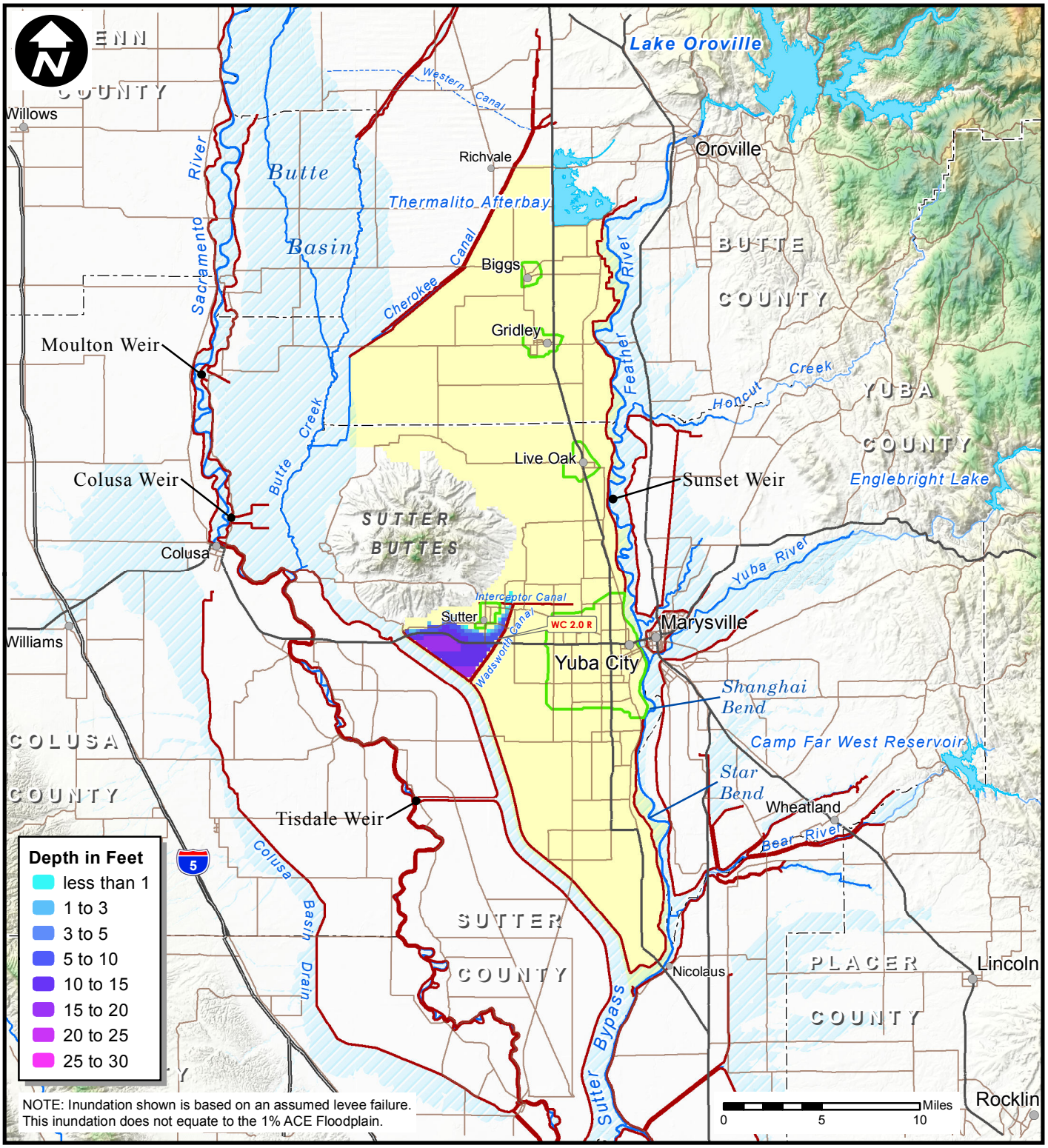
PLATE 24



Legend

- Breach Index Point
- Designated Floodways
- Lake or Reservoir
- River or Stream
- Study Area Extent
- Federal Levee
- County Boundary
- City or Town

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

MODELED BREACH INUNDATION
WC 2.0 R INDEX POINT
1% ACE EVENT

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

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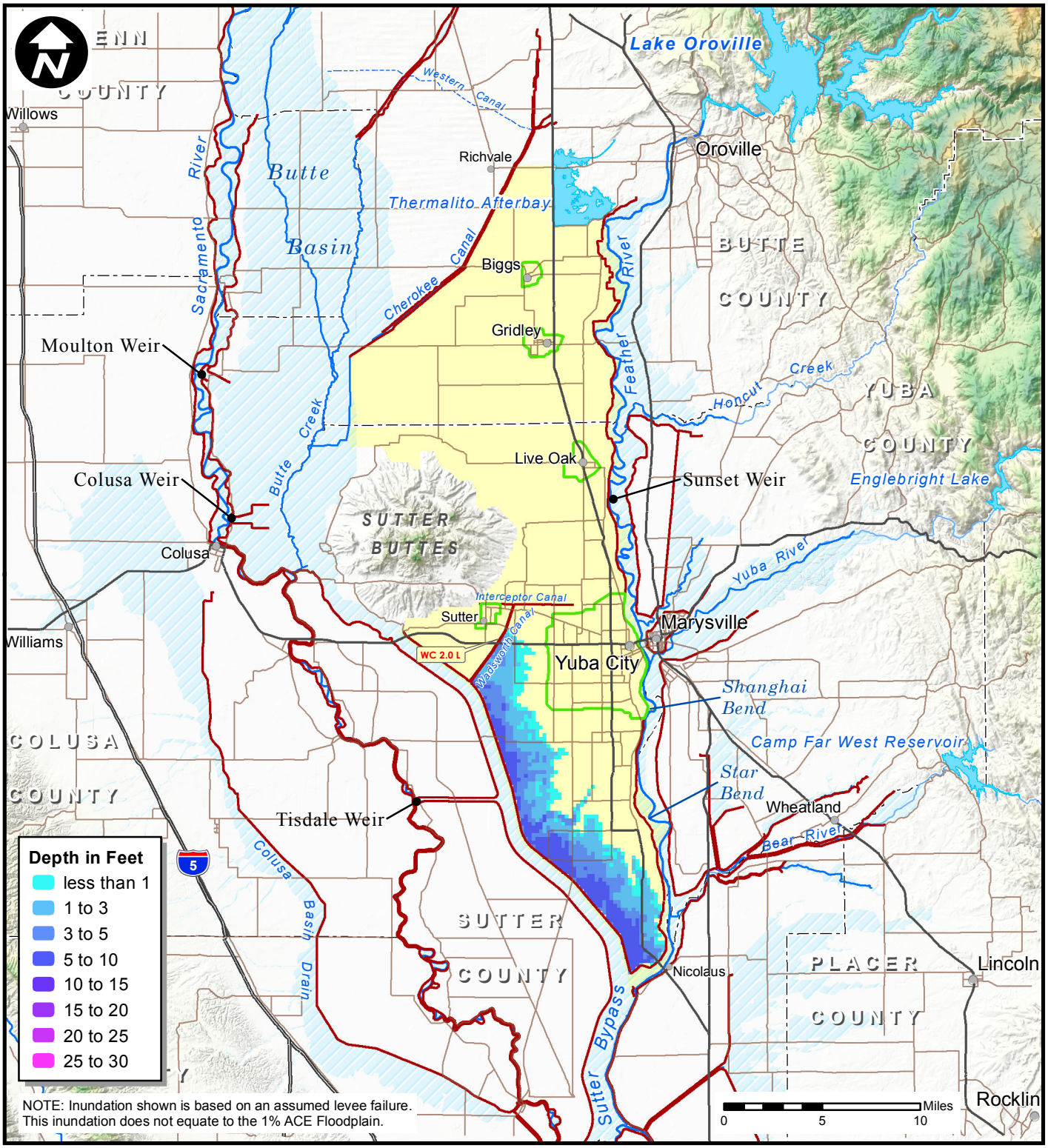
PLATE 25



Legend

- Breach Index Point
- Designated Floodways
- Lake or Reservoir
- River or Stream
- Study Area Extent
- Federal Levee
- County Boundary
- City or Town

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

MODELED BREACH INUNDATION
WC 2.0 L INDEX POINT
1% ACE EVENT

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

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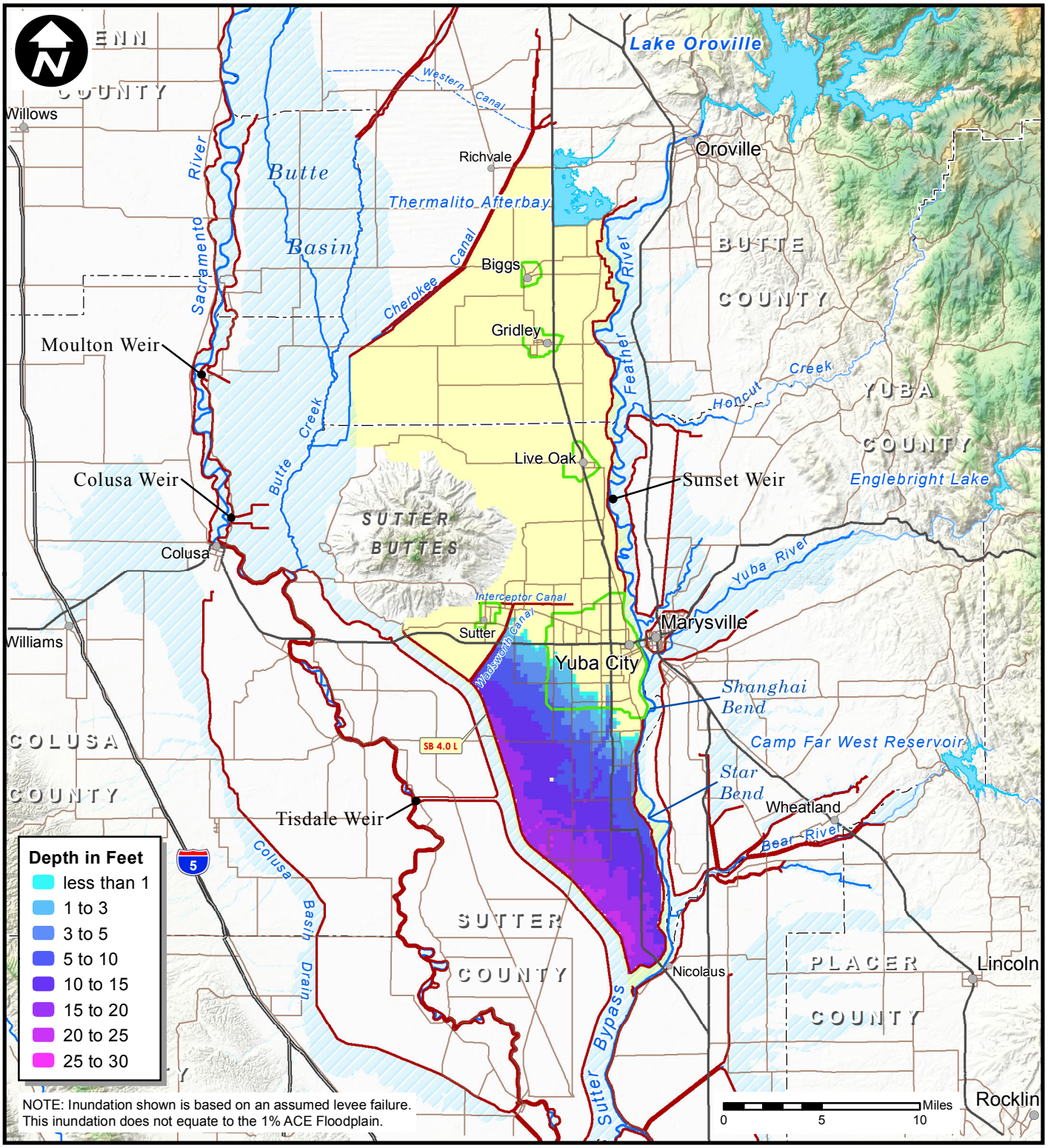
PLATE 26



Legend

- Breach Index Point
- Study Area Extent
- Designated Floodways
- Federal Levee
- Lake or Reservoir
- County Boundary
- River or Stream
- City or Town

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

MODELED BREACH INUNDATION
SB 4.0 L INDEX POINT
1% ACE EVENT

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

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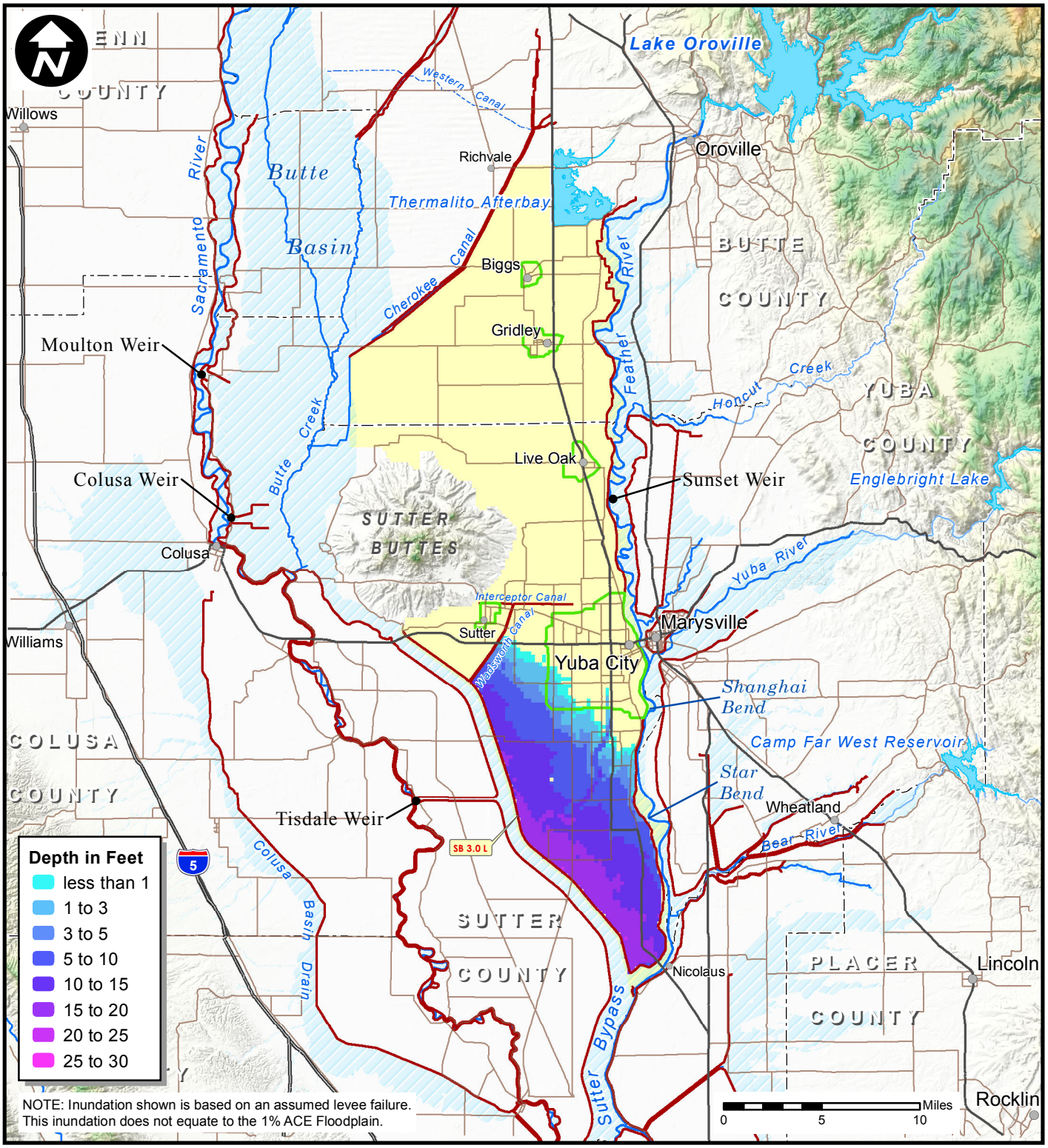
PLATE 27



Legend

- Breach Index Point
- Designated Floodways
- Lake or Reservoir
- River or Stream
- Study Area Extent
- Federal Levee
- County Boundary
- City or Town

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

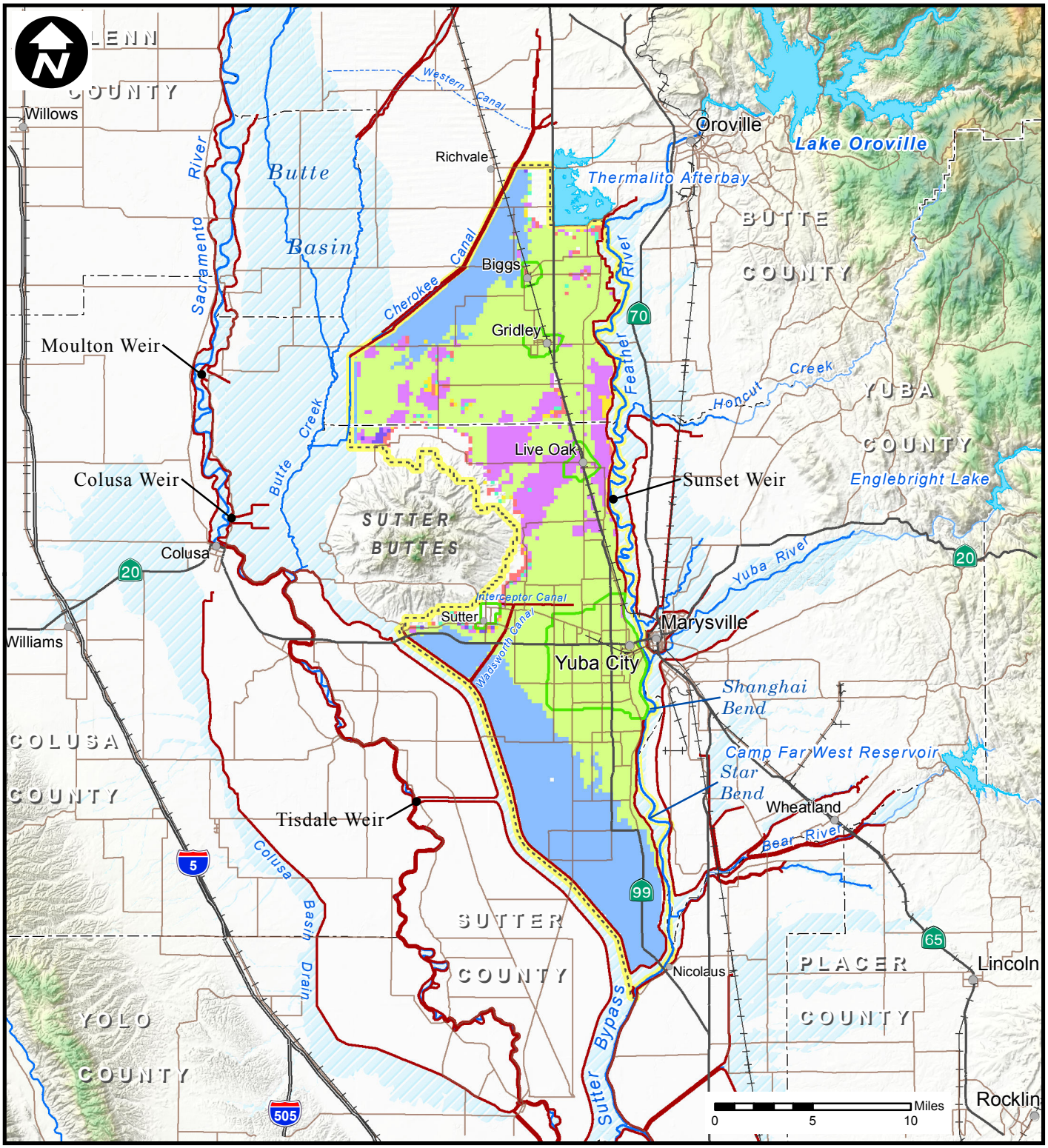
MODELED BREACH INUNDATION
SB 3.0 L INDEX POINT
1% ACE EVENT

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

OCT 2012

PLATE 28



Legend

- 0.2% (1/500) ACE Floodplain
- 0.5% (1/200) ACE Floodplain
- 1% (1/100) AEP Floodplain
- 2% (1/50) ACE Floodplain
- 4% (1/25) ACE Floodplain
- 10% (1/10) ACE Floodplain
- 50% (1/2) ACE Floodplain
- Federal Levee
- Study Area Extent
- Designated Floodways
- Lake or Reservoir
- River or Stream
- Railroad

Criteria 1 residual floodplain shown if geotechnical probability of failue is greater than 5% at median top of levee or top of levee less than 3 feet above median water surface elevation,

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

CRITERIA 1 RESIDUAL FLOODPLAIN ALTERNATIVE SB-1 WITHOUT PROJECT

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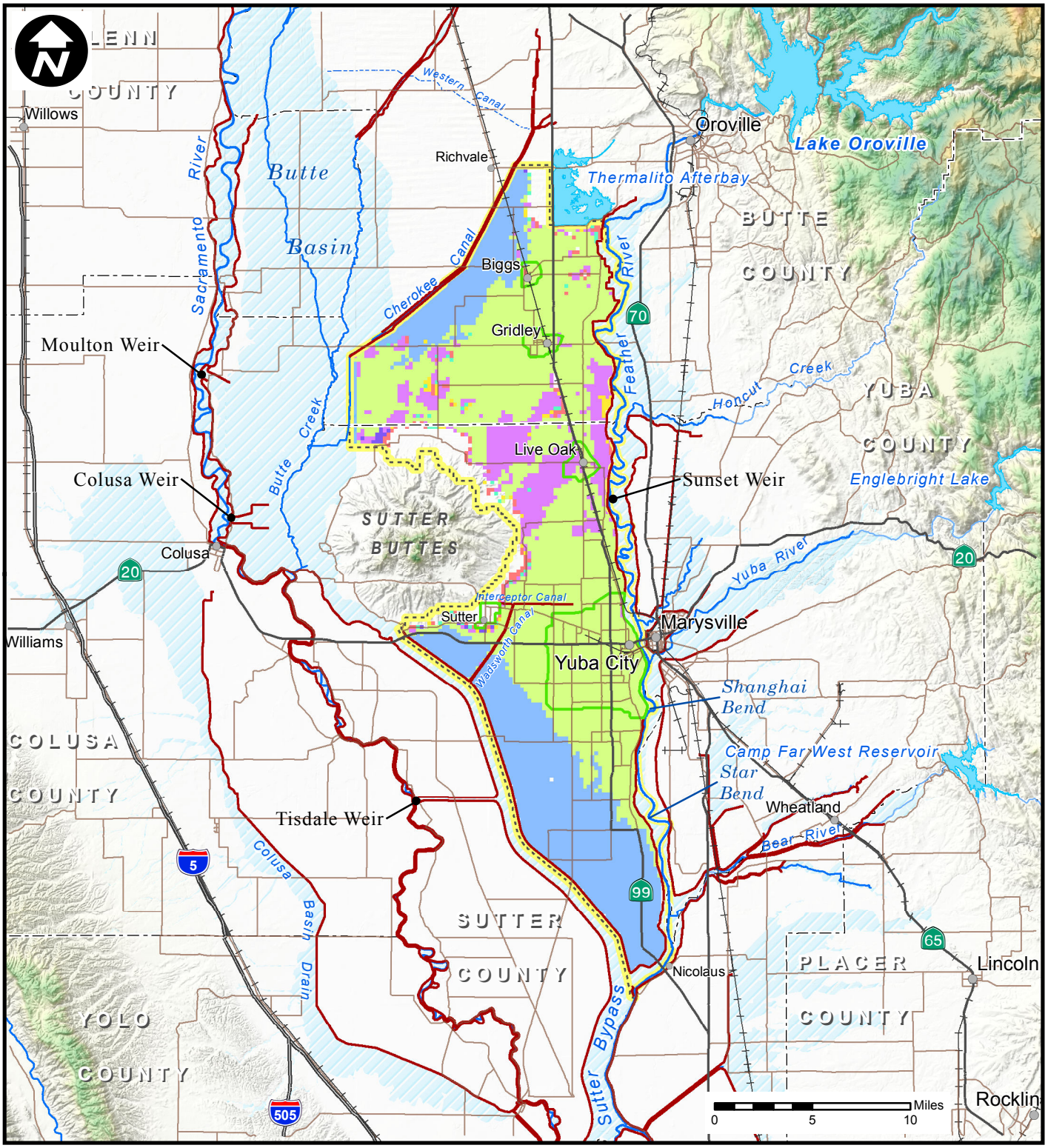
SACRAMENTO DISTRICT

Prepared by Jim Mars

OCT 2012

PLATE 29



Legend

- 0.2% (1/500) ACE Floodplain
- 0.5% (1/200) ACE Floodplain
- 1% (1/100) AEP Floodplain
- 2% (1/50) ACE Floodplain
- 4% (1/25) ACE Floodplain
- 10% (1/10) ACE Floodplain
- 50% (1/2) ACE Floodplain
- Federal Levee
- Study Area Extent
- Designated Floodways
- Lake or Reservoir
- River or Stream
- Railroad

Criteria 2 Residual flooplain shown if levee does not pass criteria.
1) Assurance less than 90% the levee does not pass criteria
2) For assurance between 90 and 95% levee must have minimum of 3 feet of freeboard to pass criteria. 3) For assurance greater than 95% levee must have minimum of 2 feet of freeboard to pass criteria

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

CRITERIA 2 RESIDUAL FLOODPLAIN ALTERNATIVE SB-1 WITHOUT PROJECT

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

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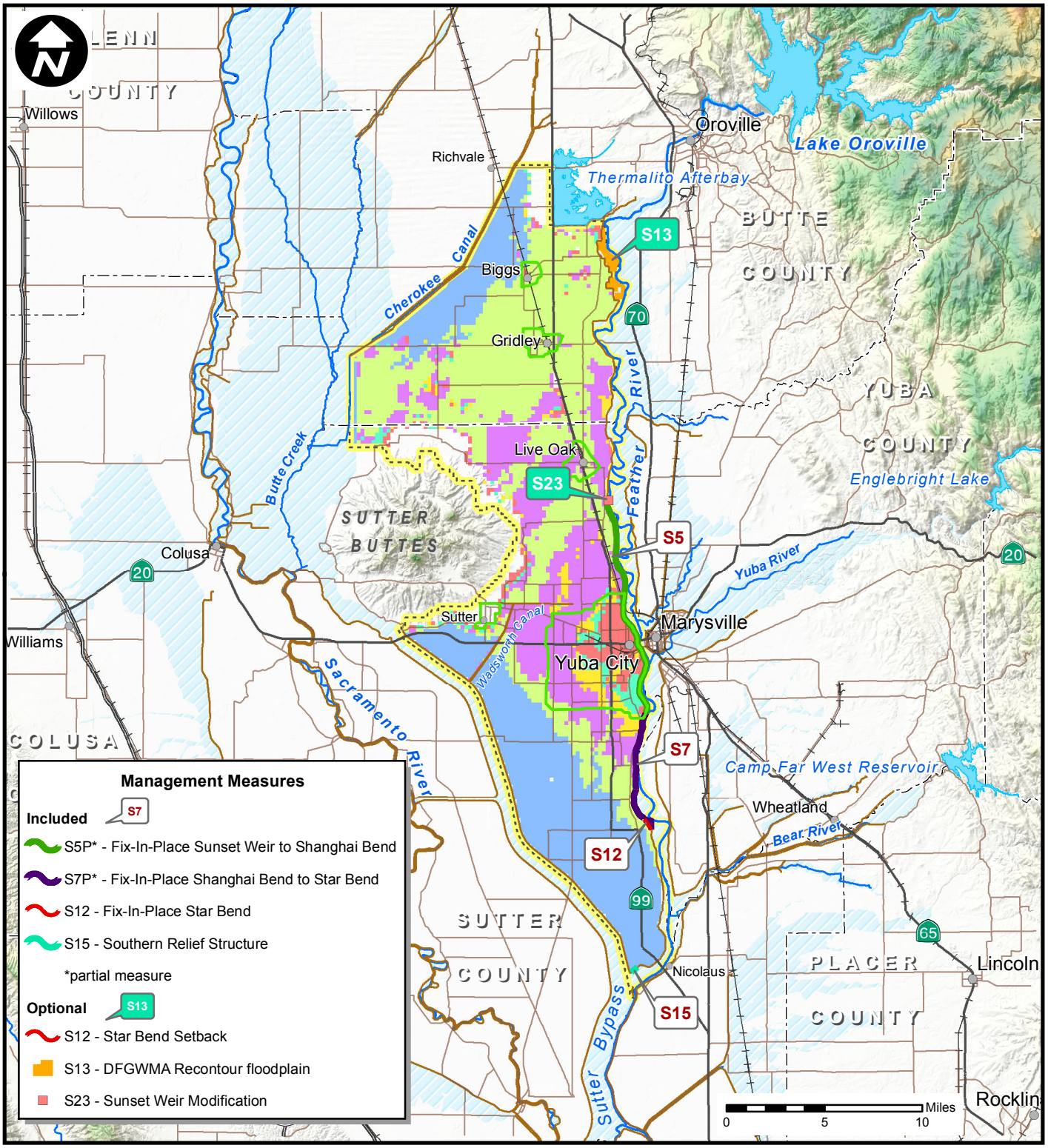
PLATE 30



Legend

- 0.2% (1/500) ACE Floodplain
- 0.5% (1/200) ACE Floodplain
- 1% (1/100) AEP Floodplain
- 2% (1/50) ACE Floodplain
- 4% (1/25) ACE Floodplain
- 10% (1/10) ACE Floodplain
- 50% (1/2) ACE Floodplain
- Federal Levee
- Study Area Extent
- Designated Floodways
- Lake or Reservoir
- River or Stream
- Railroad

Criteria 1 residual floodplain shown if geotechnical probability of failue is greater than 5% at median top of levee or top of levee less than 3 feet above median water surface elevation,

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

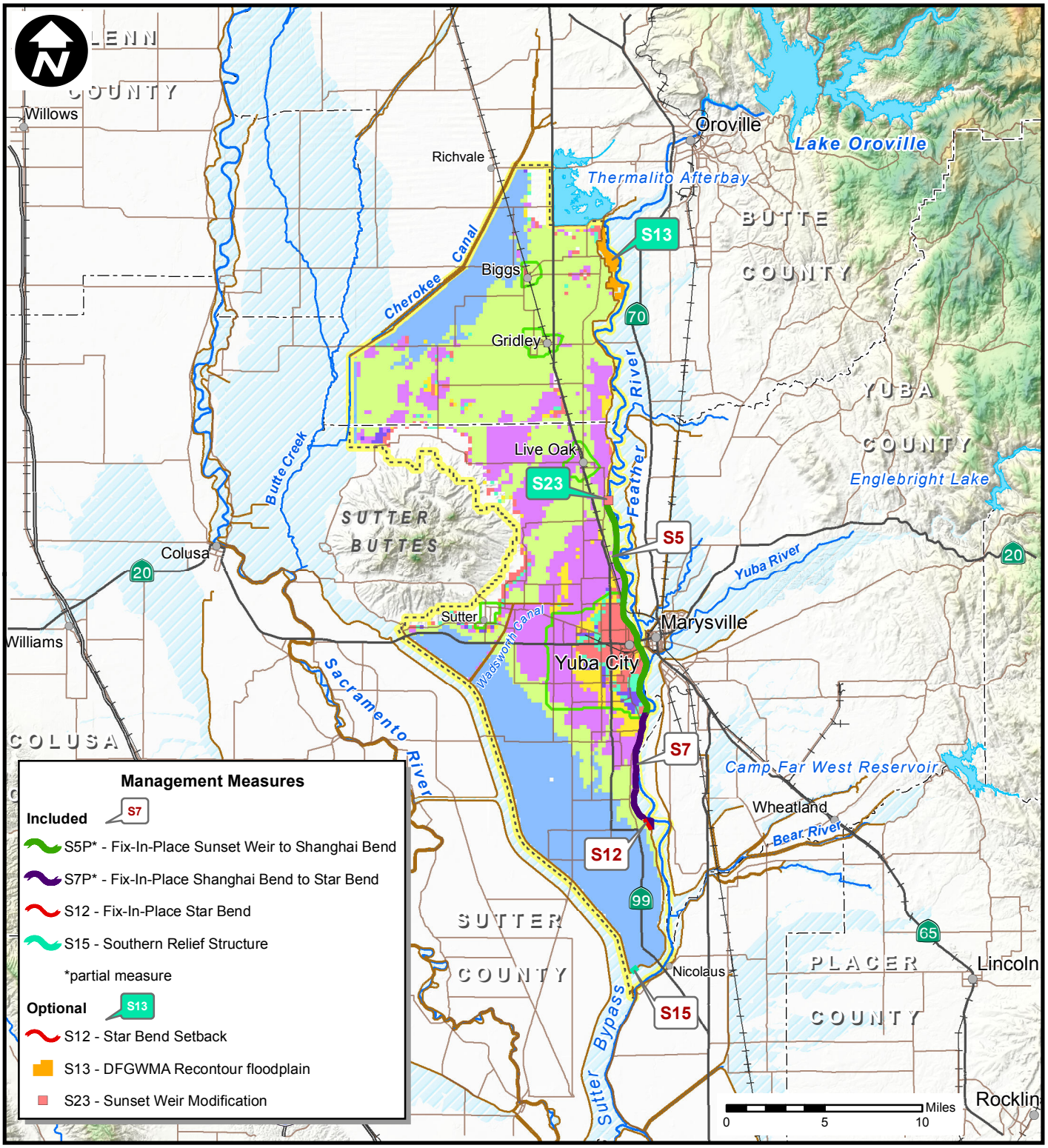
CRITERIA 1 RESIDUAL FLOODPLAIN ALTERNATIVE SB-2 MINIMAL FIX-IN-PLACE PLUS NONSTRUCTURAL

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

OCT 2012

PLATE 31



Legend

- 0.2% (1/500) ACE Floodplain
- 0.5% (1/200) ACE Floodplain
- 1% (1/100) AEP Floodplain
- 2% (1/50) ACE Floodplain
- 4% (1/25) ACE Floodplain
- 10% (1/10) ACE Floodplain
- 50% (1/2) ACE Floodplain
- Federal Levee
- Study Area Extent
- Designated Floodways
- Lake or Reservoir
- River or Stream
- Railroad

Criteria 2 Residual flooplain shown if levee does not pass criteria.
1) Assurance less than 90% the levee does not pass criteria
2) For assurance between 90 and 95% levee must have minimum of 3 feet of freeboard to pass criteria. 3) For assurance greater than 95% levee must have minimum of 2 feet of freeboard to pass criteria

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

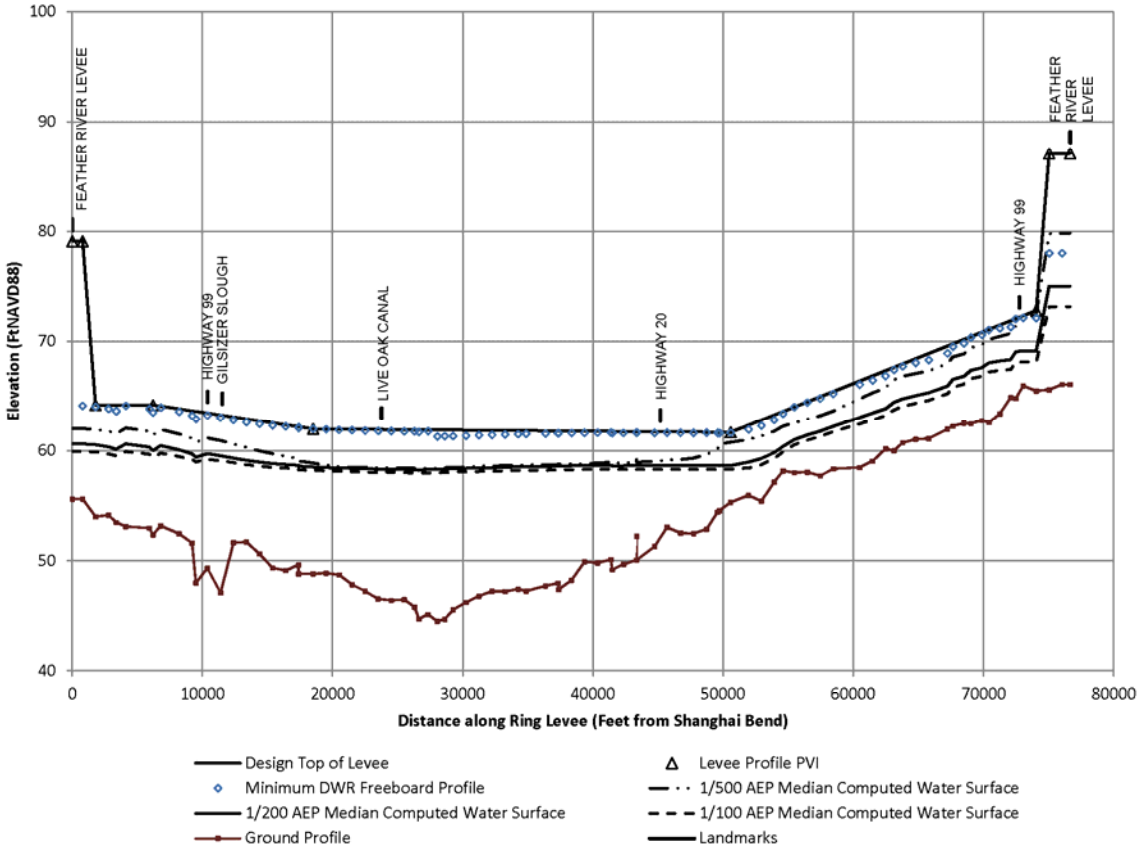
CRITERIA 2 RESIDUAL FLOODPLAIN ALTERNATIVE SB-2 MINIMAL FIX-IN-PLACE PLUS NONSTRUCTURAL

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

OCT 2012

PLATE 32



Notes:

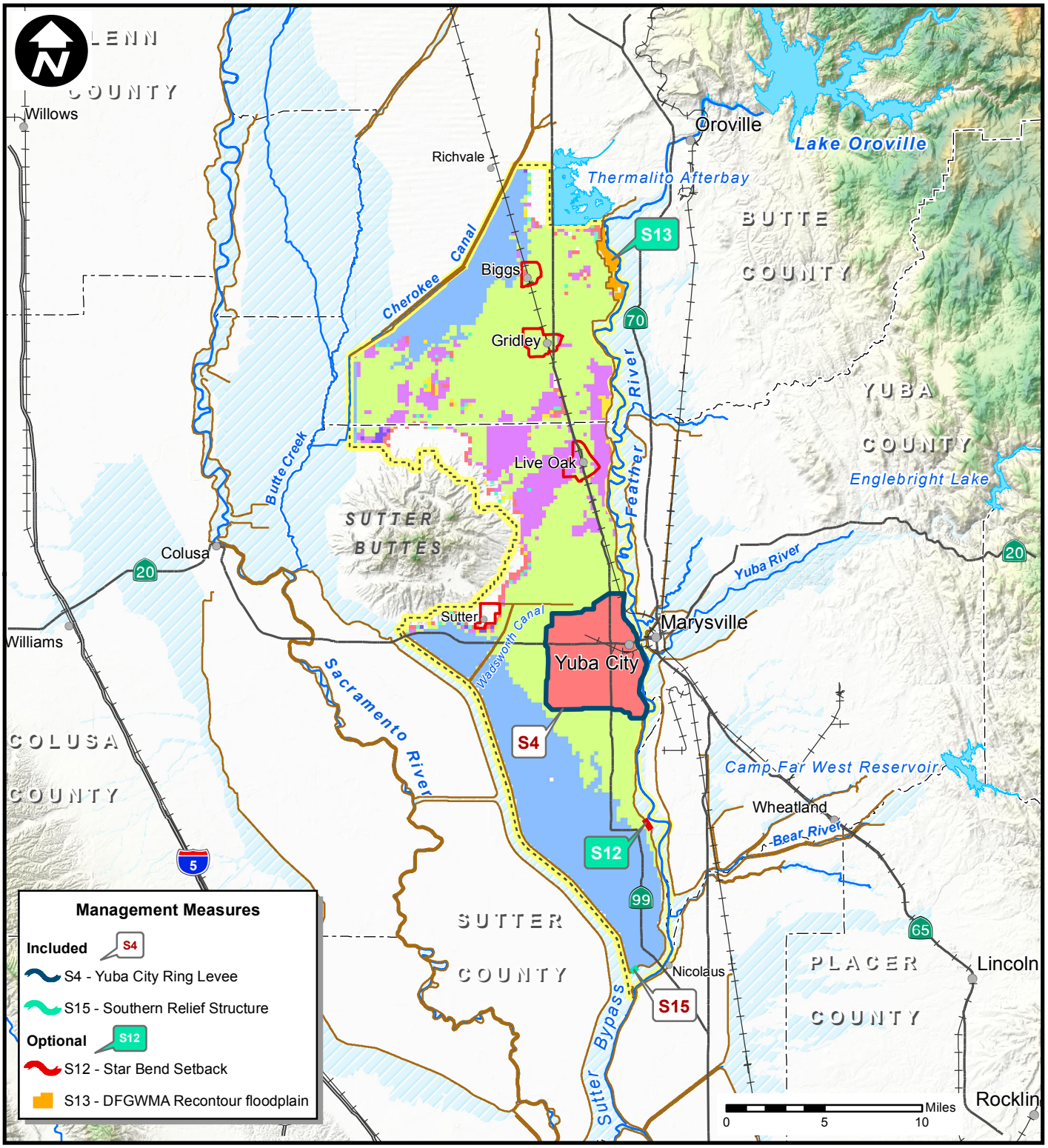
1) WSEL = Water Surface Elevation

2) Water surface elevations based on maximum water surface from assumed levee breaches outside the ring levee.

SUTTER BASIN FEASBILITY STUDY
SUTTER BASIN, CALIFORNIA

LEVEE DESIGN PROFILE
ALTERNATIVE SB-3
YUBA CITY RING LEVEE

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT



Legend

- 0.2% (1/500) ACE Floodplain
- 0.5% (1/200) ACE Floodplain
- 1% (1/100) AEP Floodplain
- 2% (1/50) ACE Floodplain
- 4% (1/25) ACE Floodplain
- 10% (1/10) ACE Floodplain
- 50% (1/2) ACE Floodplain
- Federal Levee
- Study Area Extent
- Designated Floodways
- Lake or Reservoir
- River or Stream
- Railroad

Criteria 1 residual floodplain shown if geotechnical probability of failue is greater than 5% at median top of levee or top of levee less than 3 feet above median water surface elevation,

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

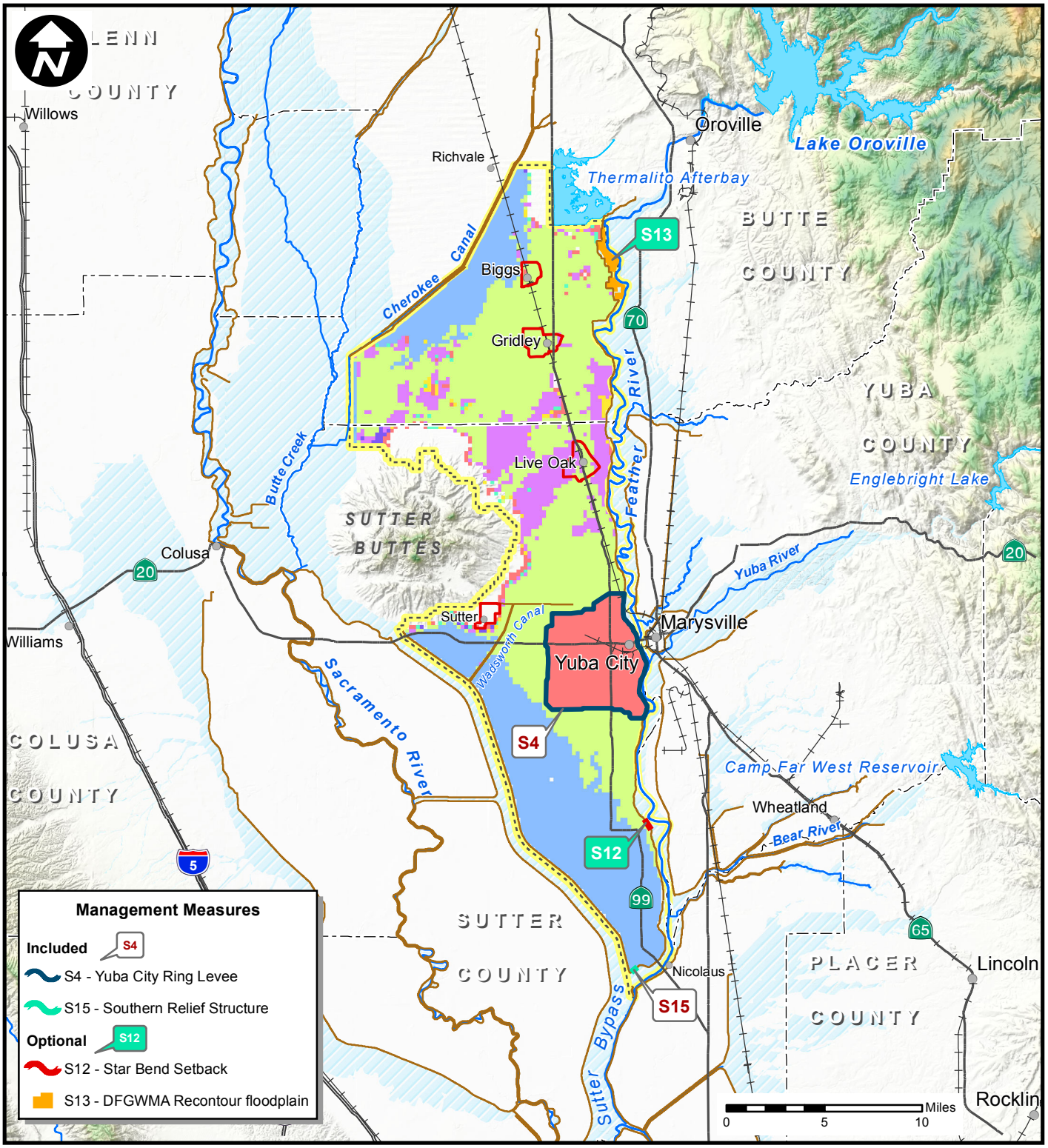
CRITERIA 1 RESIDUAL FLOODPLAIN ALTERNATIVE SB-3 YUBA CITY RING LEVEE

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

OCT 2012

PLATE 34



Legend

- 0.2% (1/500) ACE Floodplain
- 0.5% (1/200) ACE Floodplain
- 1% (1/100) AEP Floodplain
- 2% (1/50) ACE Floodplain
- 4% (1/25) ACE Floodplain
- 10% (1/10) ACE Floodplain
- 50% (1/2) ACE Floodplain
- Federal Levee
- Study Area Extent
- Designated Floodways
- Lake or Reservoir
- River or Stream
- Railroad

Criteria 2 Residual flooplain shown if levee does not pass criteria.
1) Assurance less than 90% the levee does not pass criteria
2) For assurance between 90 and 95% levee must have minimum of 3 feet of freeboard to pass criteria. 3) For assurance greater than 95% levee must have minimum of 2 feet of freeboard to pass criteria

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

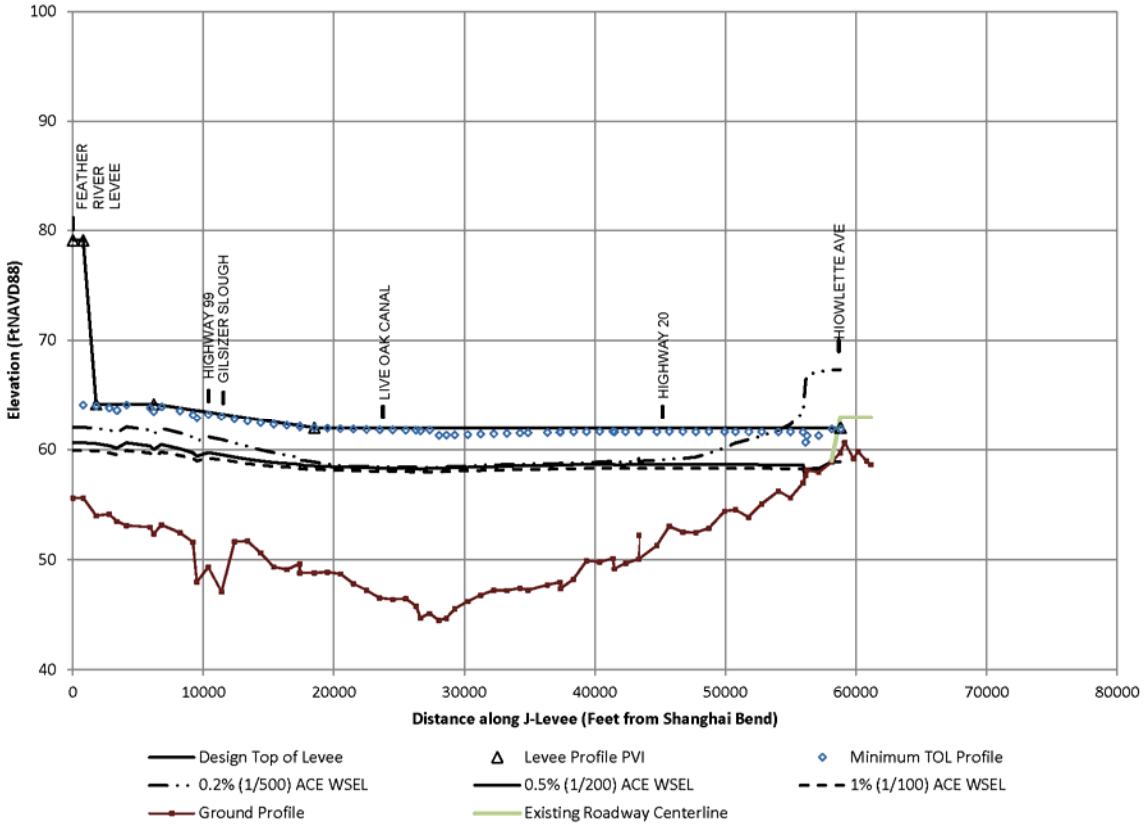
CRITERIA 2 RESIDUAL FLOODPLAIN ALTERNATIVE SB-3 YUBA CITY RING LEVEE

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

OCT 2012

PLATE 35



Notes:

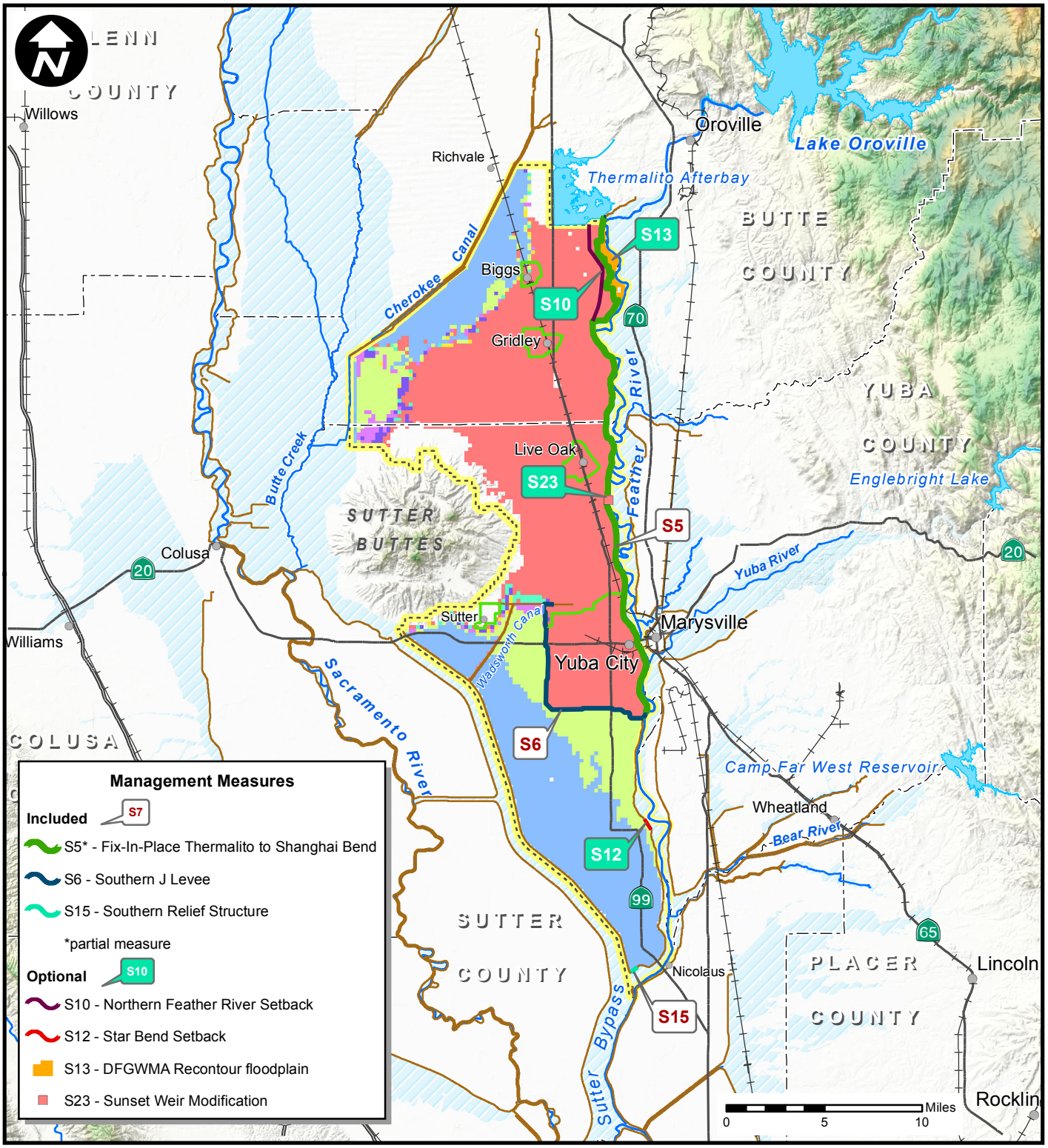
1) WSEL = Water Surface Elevation

2) Water surface elevations based on maximum water surface from assumed levee breaches outside the ring levee.

SUTTER BASIN FEASBILITY STUDY
SUTTER BASIN, CALIFORNIA

LEVEE DESIGN PROFILE
ALTERNATIVE SB-4
LITTLE "J" LEVEE

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT



Legend

- 0.2% (1/500) ACE Floodplain
- 0.5% (1/200) ACE Floodplain
- 1% (1/100) AEP Floodplain
- 2% (1/50) ACE Floodplain
- 4% (1/25) ACE Floodplain
- 10% (1/10) ACE Floodplain
- 50% (1/2) ACE Floodplain
- Federal Levee
- Study Area Extent
- Designated Floodways
- Lake or Reservoir
- River or Stream
- Railroad

Criteria 1 residual floodplain shown if geotechnical probability of failue is greater than 5% at median top of levee or top of levee less than 3 feet above median water surface elevation,

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

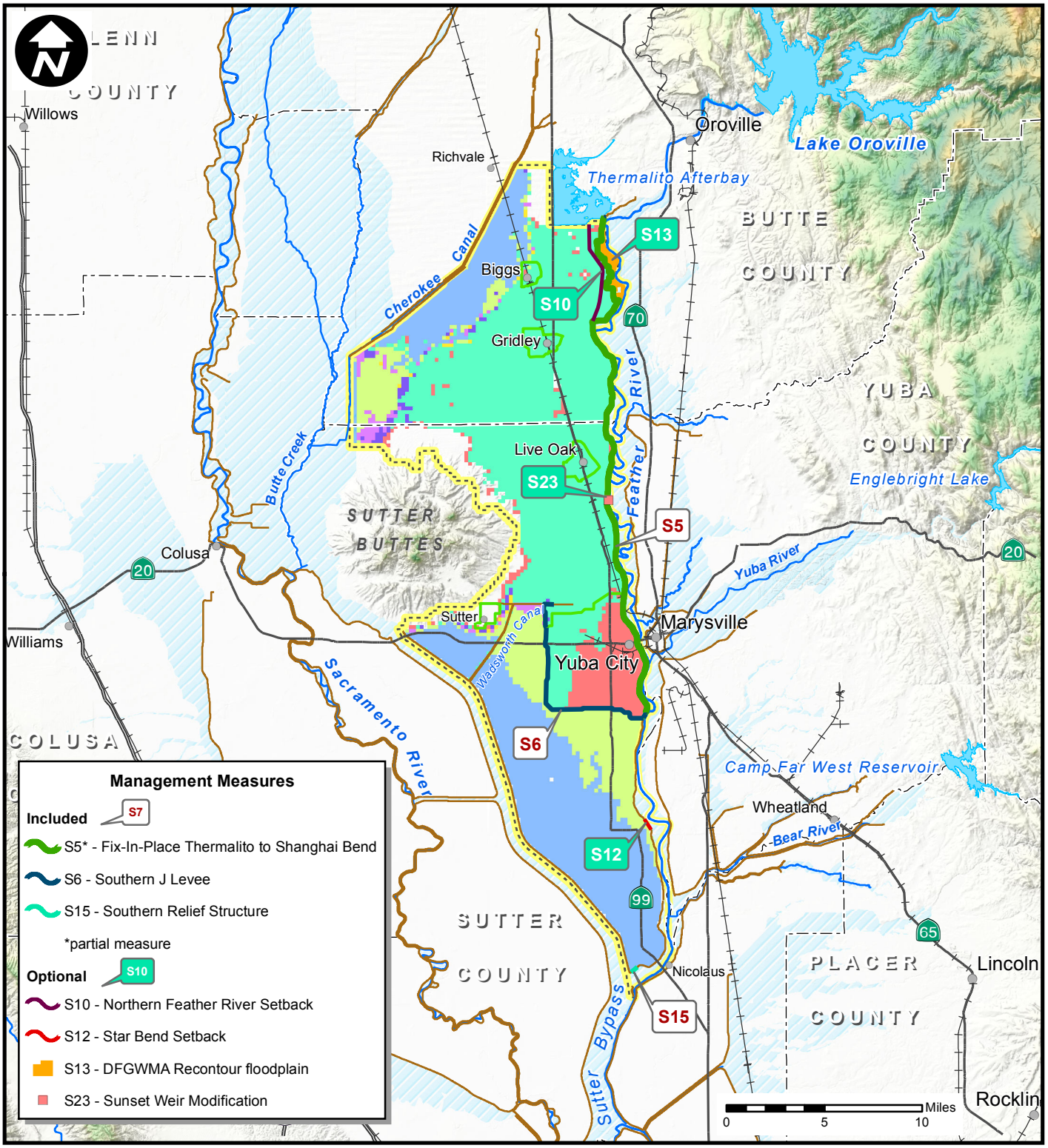
CRITERIA 1 RESIDUAL FLOODPLAIN ALTERNATIVE SB-4 LITTLE "J" LEVEE

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

OCT 2012

PLATE 37



Legend

- 0.2% (1/500) ACE Floodplain
- 0.5% (1/200) ACE Floodplain
- 1% (1/100) AEP Floodplain
- 2% (1/50) ACE Floodplain
- 4% (1/25) ACE Floodplain
- 10% (1/10) ACE Floodplain
- 50% (1/2) ACE Floodplain
- Federal Levee
- Study Area Extent
- Designated Floodways
- Lake or Reservoir
- River or Stream
- Railroad

Criteria 2 Residual flooplain shown if levee does not pass criteria.
1) Assurance less than 90% the levee does not pass criteria
2) For assurance between 90 and 95% levee must have minimum of 3 feet of freeboard to pass criteria. 3) For assurance greater than 95% levee must have minimum of 2 feet of freeboard to pass criteria

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

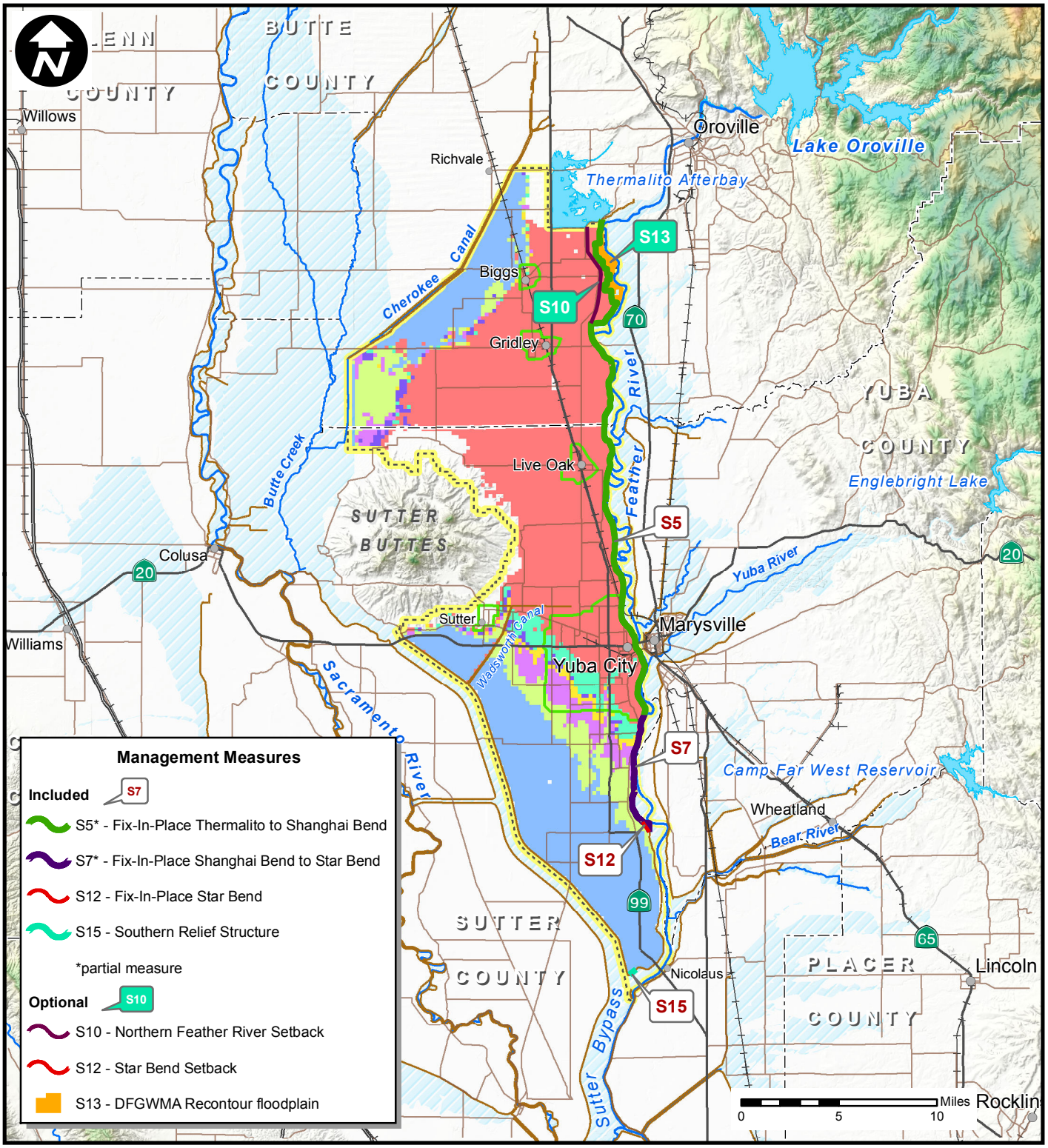
CRITERIA 2 RESIDUAL FLOODPLAIN ALTERNATIVE SB-4 LITTLE "J" LEVEE

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

OCT 2012

PLATE 38



Legend

- 0.2% (1/500) ACE Floodplain
- 0.5% (1/200) ACE Floodplain
- 1% (1/100) AEP Floodplain
- 2% (1/50) ACE Floodplain
- 4% (1/25) ACE Floodplain
- 10% (1/10) ACE Floodplain
- 50% (1/2) ACE Floodplain
- Federal Levee
- Study Area Extent
- Designated Floodways
- Lake or Reservoir
- River or Stream
- Railroad

Criteria 1 residual floodplain shown if geotechnical probability of failue is greater than 5% at median top of levee or top of levee less than 3 feet above median water surface elevation,

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

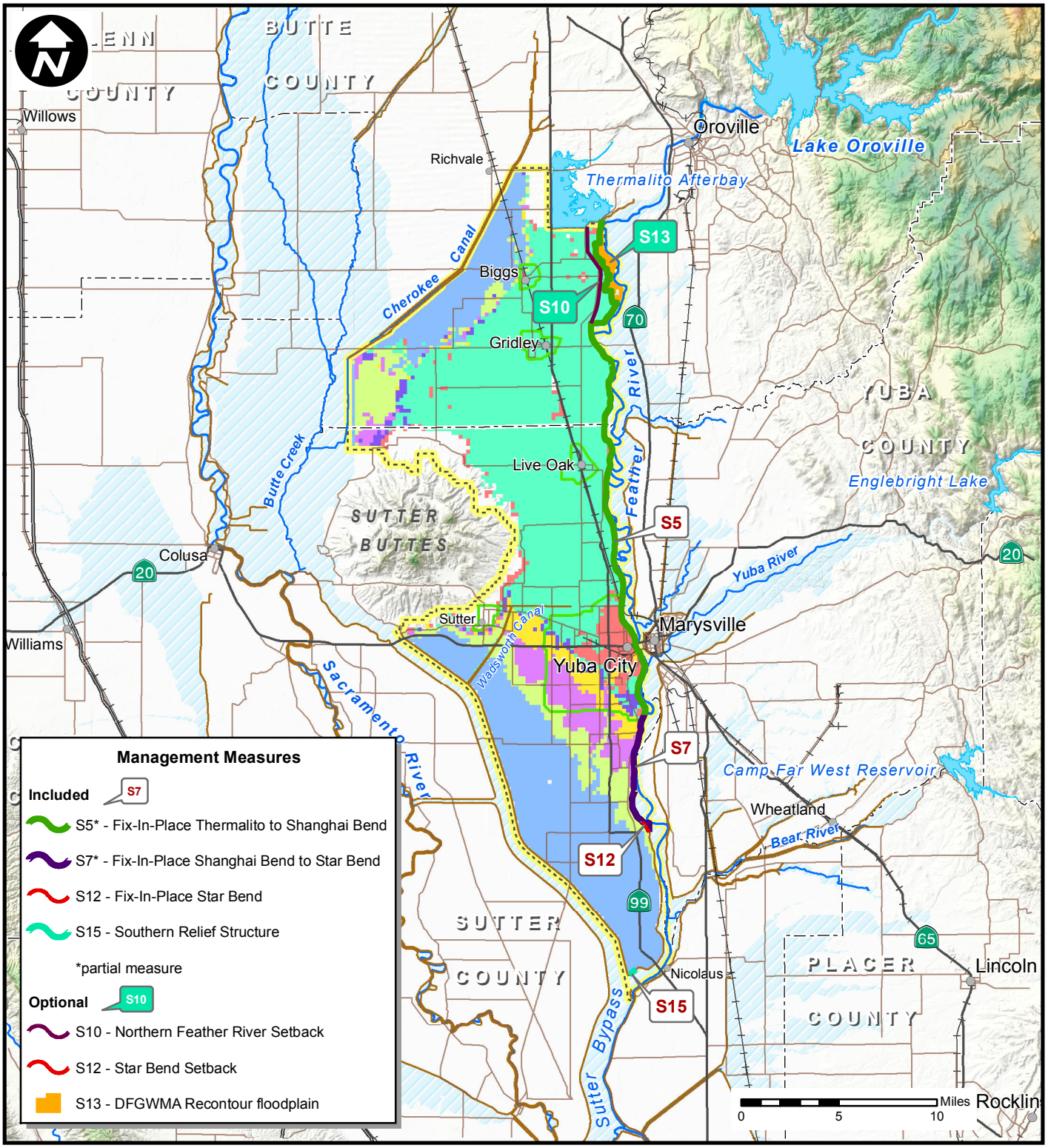
CRITERIA 1 RESIDUAL FLOODPLAIN ALTERNATIVE SB-5 FIX IN PLACE FEATHER RIVER, THERMALITO TO STAR BEND

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

OCT 2012

PLATE 39



Legend

- 0.2% (1/500) ACE Floodplain
- 0.5% (1/200) ACE Floodplain
- 1% (1/100) AEP Floodplain
- 2% (1/50) ACE Floodplain
- 4% (1/25) ACE Floodplain
- 10% (1/10) ACE Floodplain
- 50% (1/2) ACE Floodplain
- Federal Levee
- Study Area Extent
- Designated Floodways
- Lake or Reservoir
- River or Stream
- Railroad

Criteria 2 Residual flooplain shown if levee does not pass criteria.
1) Assurance less than 90% the levee does not pass criteria
2) For assurance between 90 and 95% levee must have minimum of 3 feet of freeboard to pass criteria. 3) For assurance greater than 95% levee must have minimum of 2 feet of freeboard to pass criteria

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

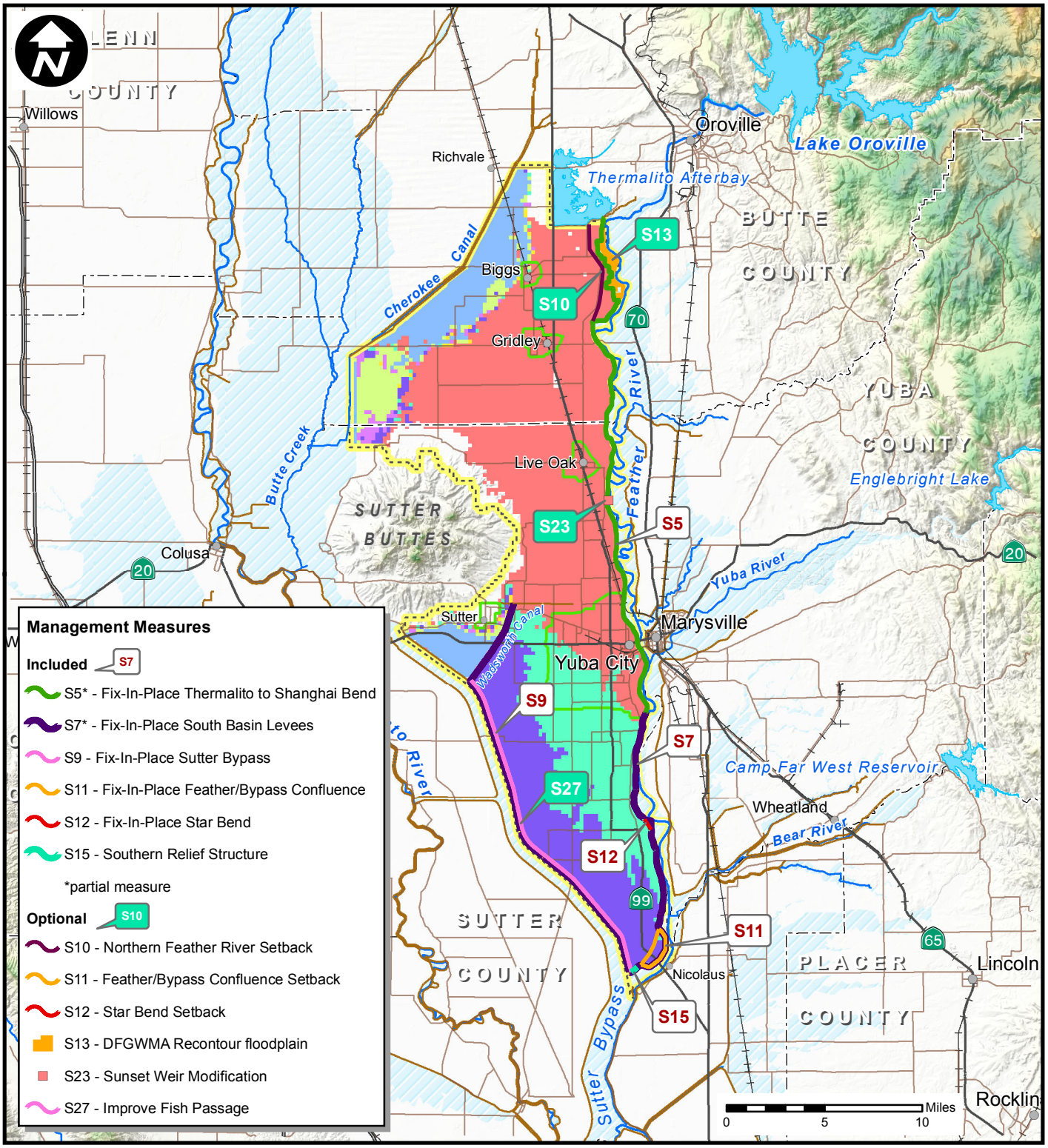
CRITERIA 2 RESIDUAL FLOODPLAIN ALTERNATIVE SB-5 FIX IN PLACE FEATHER RIVER, THERMALITO TO STAR BEND

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

OCT 2012

PLATE 40



Legend

- 0.2% (1/500) ACE Floodplain
- 0.5% (1/200) ACE Floodplain
- 1% (1/100) AEP Floodplain
- 2% (1/50) ACE Floodplain
- 4% (1/25) ACE Floodplain
- 10% (1/10) ACE Floodplain
- 50% (1/2) ACE Floodplain
- Federal Levee
- Study Area Extent
- Designated Floodways
- Lake or Reservoir
- River or Stream
- Railroad

Criteria 1 residual floodplain shown if geotechnical probability of failue is greater than 5% at median top of levee or top of levee less than 3 feet above median water surface elevation,

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

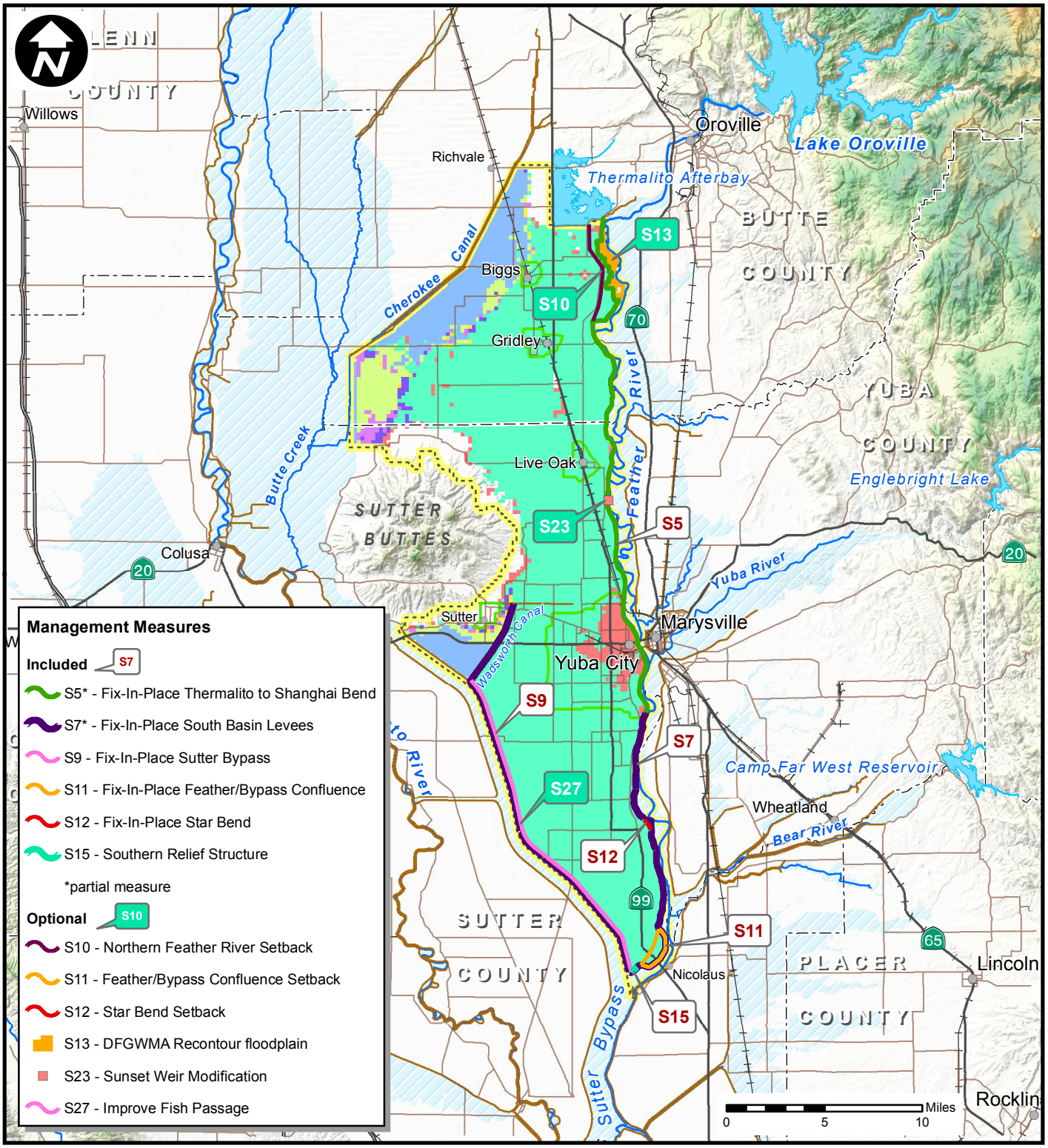
CRITERIA 1 RESIDUAL FLOODPLAIN ALTERNATIVE SB-6 FIX IN PLACE FEATHER RIVER, SUTTER BYPASS, AND WADSWORTH

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

OCT 2012

PLATE 41



Legend

- 0.2% (1/500) ACE Floodplain
- 0.5% (1/200) ACE Floodplain
- 1% (1/100) AEP Floodplain
- 2% (1/50) ACE Floodplain
- 4% (1/25) ACE Floodplain
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- 50% (1/2) ACE Floodplain
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- Study Area Extent
- Designated Floodways
- Lake or Reservoir
- River or Stream
- Railroad

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SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

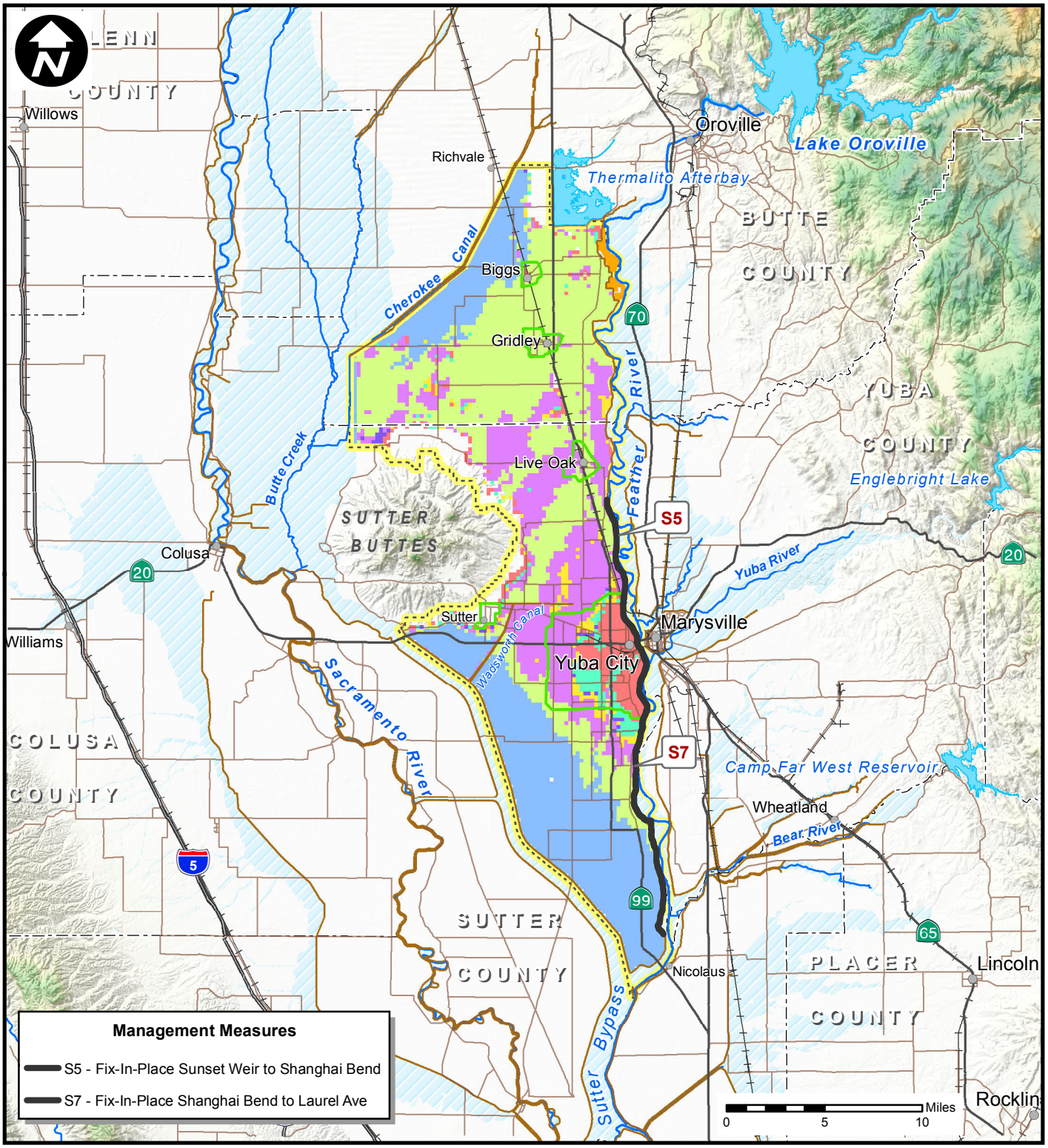
CRITERIA 2 RESIDUAL FLOODPLAIN ALTERNATIVE SB-6 FIX IN PLACE FEATHER RIVER, SUTTER BYPASS, AND WADSWORTH

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

OCT 2012

PLATE 42



Legend

- 0.2% (1/500) ACE Floodplain
- 0.5% (1/200) ACE Floodplain
- 1% (1/100) AEP Floodplain
- 2% (1/50) ACE Floodplain
- 4% (1/25) ACE Floodplain
- 10% (1/10) ACE Floodplain
- 50% (1/2) ACE Floodplain
- Federal Levee
- Study Area Extent
- Designated Floodways
- Lake or Reservoir
- River or Stream
- Railroad

Criteria 1 residual floodplain shown if geotechnical probability of failue is greater than 5% at median top of levee or top of levee less than 3 feet above median water surface elevation,

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

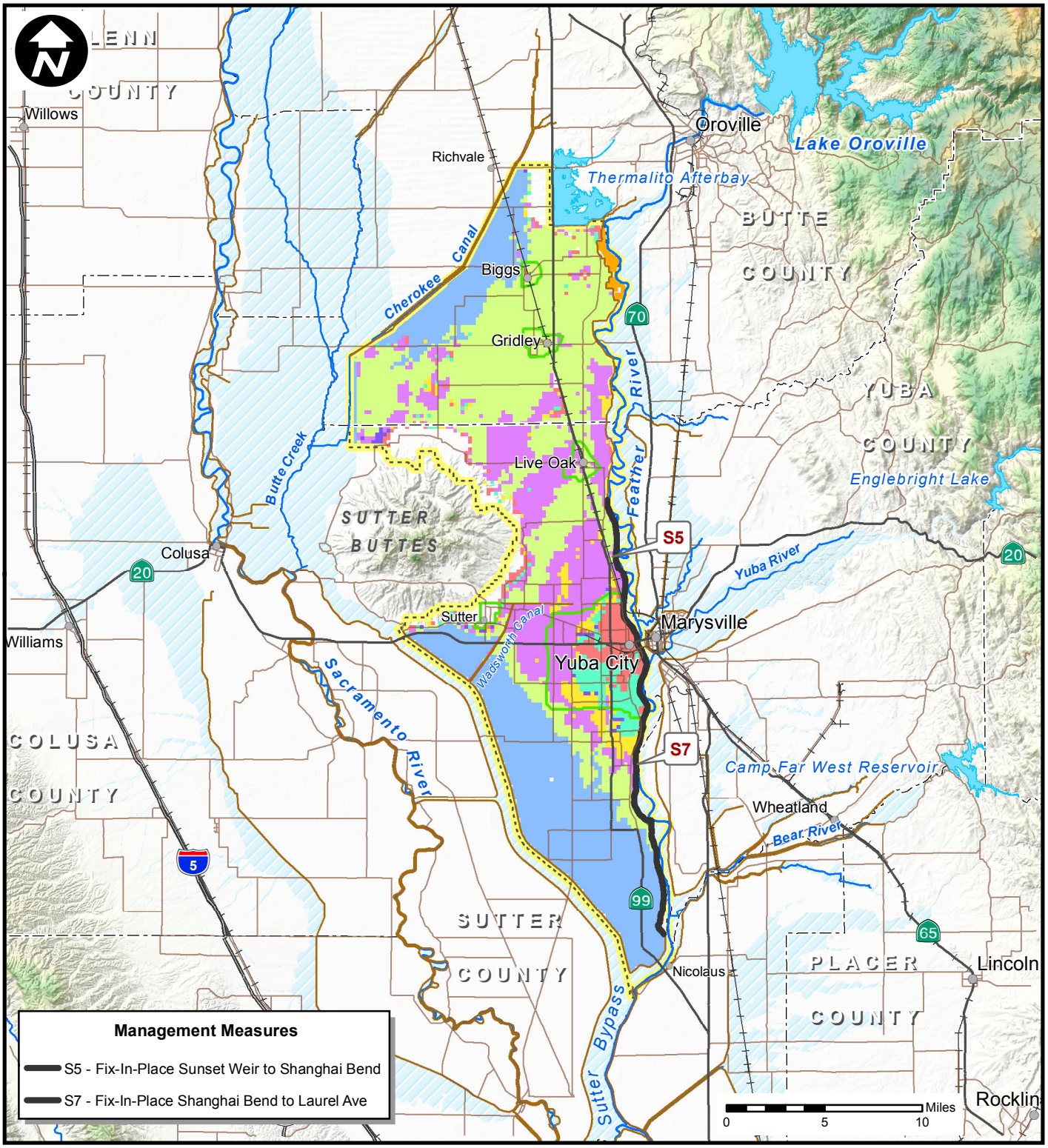
CRITERIA 1 RESIDUAL FLOODPLAIN ALTERNATIVE SB-7 FIX-IN-PLACE FEATHER RIVER SUNSET WEIR TO LAUREL AVE

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

OCT 2012

PLATE 43



Legend

- 0.2% (1/500) ACE Floodplain
- 0.5% (1/200) ACE Floodplain
- 1% (1/100) AEP Floodplain
- 2% (1/50) ACE Floodplain
- 4% (1/25) ACE Floodplain
- 10% (1/10) ACE Floodplain
- 50% (1/2) ACE Floodplain
- Federal Levee
- Study Area Extent
- Designated Floodways
- Lake or Reservoir
- River or Stream
- Railroad

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SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

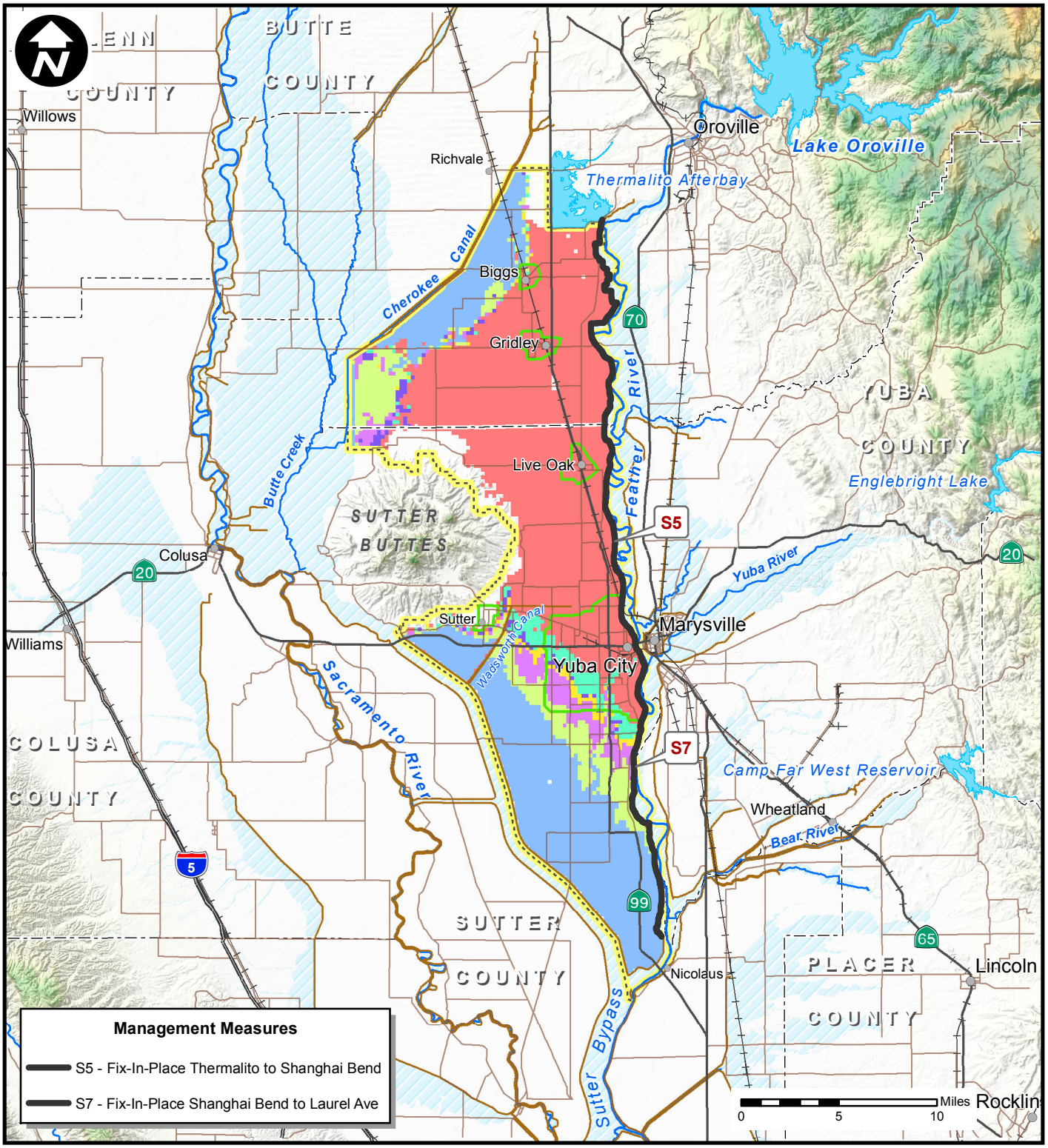
CRITERIA 2 RESIDUAL FLOODPLAIN ALTERNATIVE SB-7 FIX-IN-PLACE FEATHER RIVER SUNSET WEIR TO LAUREL AVE

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

OCT 2012

PLATE 44



Legend

- 0.2% (1/500) ACE Floodplain
- 0.5% (1/200) ACE Floodplain
- 1% (1/100) AEP Floodplain
- 2% (1/50) ACE Floodplain
- 4% (1/25) ACE Floodplain
- 10% (1/10) ACE Floodplain
- 50% (1/2) ACE Floodplain
- Federal Levee
- Study Area Extent
- Designated Floodways
- Lake or Reservoir
- River or Stream
- Railroad

Criteria 1 residual floodplain shown if geotechnical probability of failue is greater than 5% at median top of levee or top of levee less than 3 feet above median water surface elevation,

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

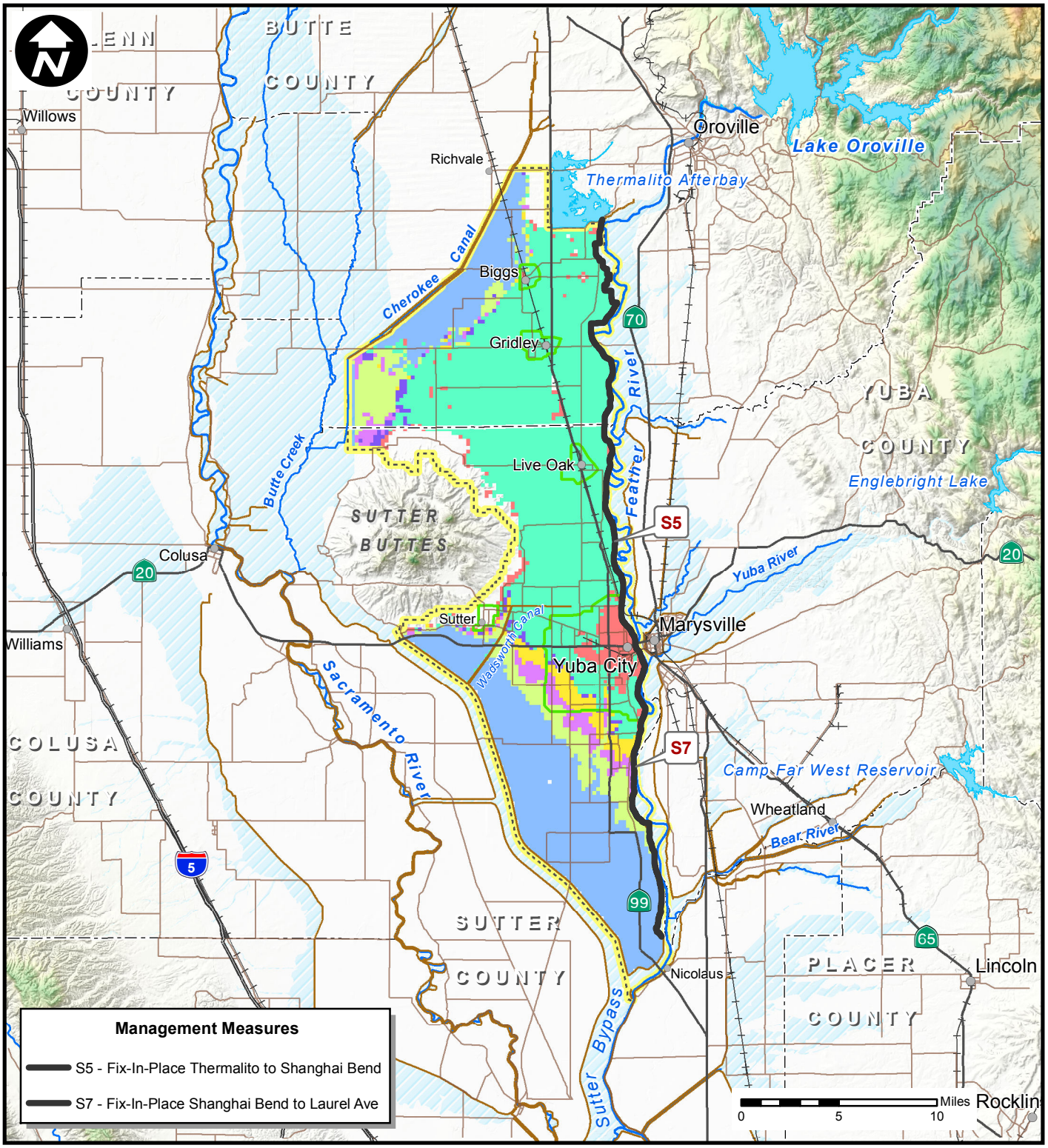
CRITERIA 1 RESIDUAL FLOODPLAIN ALTERNATIVE SB-8 FIX IN PLACE FEATHER RIVER, THERMALITO TO LAUREL AVE

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

OCT 2012

PLATE 45



Legend

- 0.2% (1/500) ACE Floodplain
- 0.5% (1/200) ACE Floodplain
- 1% (1/100) AEP Floodplain
- 2% (1/50) ACE Floodplain
- 4% (1/25) ACE Floodplain
- 10% (1/10) ACE Floodplain
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- Federal Levee
- Study Area Extent
- Designated Floodways
- Lake or Reservoir
- River or Stream
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1) Assurance less than 90% the levee does not pass criteria
2) For assurance between 90 and 95% levee must have minimum of 3 feet of freeboard to pass criteria. 3) For assurance greater than 95% levee must have minimum of 2 feet of freeboard to pass criteria

SUTTER BASIN PILOT FEASIBILITY STUDY
SUTTER BASIN, CALIFORNIA

CRITERIA 2 RESIDUAL FLOODPLAIN ALTERNATIVE SB-8 FIX IN PLACE FEATHER RIVER, THERMALITO TO LAUREL AVE

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by Jim Mars

OCT 2012

PLATE 46